"I wish we could derive the rest of the phenomena of nature by the same kind of reasoning from mechanical principles; for I am induced by many reasons to suspect that they may all depend upon certain forces by which the particles of bodies, by some causes hitherto unknown, are either mutually impelled towards each other, and cohere in regular figures, or are repelled and recede from each other."

Isaac Newton
The Principia[1]
Cambridge, Trinity College, 1686

"We have the electrical and magnetic sciences, which treat of certain phenomena of attraction, heat, light and chemical action, depending on conditions of matter, of which we have as yet only a partial and provisional knowledge. An immense mass of facts has been collected and these have been reduced to order, and expressed as the results of a number of experimental laws, but the form under which these laws are ultimately to appear as deduced from central principles is as yet uncertain."

James Clerk Maxwell
Inaugural Lecture[2]
Paris, Kings College, 1860

"In considering the thermodynamics of biological evolution it is convenient to examine subsystems where different processes of reaching corresponding quasi-equilibrium take place: molecular processes, chemical evolutions, supramolecular evolutions, and evolutions of higher orders such as genera, families, associations, and ecological evolutions, etc. Assuming that the corresponding quasi-equilibria are reached in the processes of general and particular evolutions of the biosphere and its subsystems one can use the Gibbs free energy criteria of equilibrium to predict the degree of evolutionary development of each process."

Georgi, P. Gladyshev
On the Thermodynamics of Biological Evolution[3]
Moscow, Institute of Chemical Physics Academy of Science, 1978

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Human Chemistry

Volume Two

LuLu, Inc.

Human Chemistry

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Shared in Noble Peace Prize, 1995[1]

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— *Tiffany Clotfelter, Age 18*, Homecoming Princess

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— *Urvaksh Patel*, BS Finance and Entrepreneurship

"I'm glad someone can see or is not afraid to look outside the prescribed scale for a change!"

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"The chapters are wonderfully written. I have a feeling that it will be (Thims) who will get the public's attention about the fundamental change in thinking in science."

— *Jing Chen*, BS, MS, and PhD Mathematics
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"I think that the date of first incorporation of iodine into biological molecular structure (as iodocarbons) might be started in *Cyanobacteria* (as a primitive antioxidant: probably the first antioxidant) about 3.5 BYA, as we reported in our works."

— *Sebastiano Venturi*, MD
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"At first, (Thims) theory looks strange, but after time, following further thought and understanding, I did not find any arguments against it … if we have rules for molecular behavior, why not adapt these molecular terms for human behavior; moreover, until human thermodynamics, there had never been a direct link between fingerprints, which reflect the character and health of a person, and DNA – this phenomenon can now be explained."

— *Viktor Minkin*, BS Measurement and IT, MS Photosensitive Devices
Cofounder: Vibraimage Technologies[4]

"I think (Thims) should take a bunch of copies of (his) book, go downtown to a street corner, and just start talking!"

— *Edward Duncan, Graphic Designer*

Contents:

> A structure becomes architecture and not sculpture when its elements no longer have their justification in nature.
>
> *Guillaume Apollinaire,* French Poet

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Intermission:

> Each (person) who receives a liberal education today counts chemistry as one of the indispensable parts of his (or her) studies.
> *Antoine de Fourcroy,* French Chemist

This two-volume book on modern human chemistry was originally intended to be one single short booklet. The reader should consider it so. Namely, chapters one through sixteen should be read straight-through, start-to-finish.

Volume one consists of the basis of elementary concepts in human chemistry, namely human molecules, human chemical reactions, heat, photons, electrons, nuclei, rates of reactions, reaction kinetics, Carnot work cycles, energy, enthalpy, entropy, work, thermodynamic systems, the laws of thermodynamics, molecular evolution, mate desirability factors, attraction, repulsion, ambivalence, Gottman stability ratios, Feynman diagrams, exchange force, valency, quantum chemistry, fundamental interactions, human molecular orbital theory, the dodecabond model, and collision theory, among others.

Volume two is a continuation of these basics, beginning with Goethe's theories of human affinities, i.e. the chemical reaction view of human life in the year 1809. This is followed by the historical development of how affinity chemistry was slowly replaced by the modern-day conceptions of quantum electron orbital 'valency', i.e. bond stabilities, and chemical thermodynamic 'free energy', i.e. reaction spontaneity; quantities which are now used to understand modern human reaction life through the tools of chemical bonding and reaction feasibility.

The centerpiece of volume two is the theory of *human chemical bonding*, which aside *human chemical thermodynamics* is one of the more difficult topics to write on in a rigorous form. The essential focal point in human life is desired mate-selection and the functional work-energy output and evolved structural formations produced therefrom. The composition, energetic state, dynamics, and evolution of the human chemical bond $A \equiv B$ is the centerpiece of this process. The human bond is what gives (yields) and takes (absorbs) energy in life. The coupling of this chemical bond energy, driven by periodic inputs of solar gamma ray photons, thus functioning to trigger activation energies and entropies, connected to the dynamical work output of life, is what quantifies the human reaction process. The composition of the human chemical bond, and exchange force mechanism operating therein, is dissected from

the psychological, psychodynamic, neurochemical, hormonal, quantum mechanical and chemical thermodynamic point of view.

This overview of the basics of human chemical bonding is followed by a quick comparative presentation of the various human bonding, as well as animal bonding, theories used historically, such as pair-bond (1930), attachment (1969), weak ties (1973), maternal-bond (1976), and limbic bond (2000), among others. A discussion of the dynamics of the debonding process and debonding theories, e.g. detachment (1969), uncoupling (1986), and placeholders (2003), etc., is included. This is followed by an introduction to a miscellany of newer key topics, including mental crystallization, template theory, LGBT or queer chemistry, chemical potential, flow chemistry, Le Chatelier's principle, and Müller dispersion forces.

The last chapter introduces the reader to the more advanced topic of human thermodynamics, which assumes an *a priori* knowledge that the human being is a reactive molecule attached to substrate. This latter point is the core fact of human chemistry. If the inquisitive reader has learned anything from the first fifteen chapters, it should be the reality that *humans are reactive molecules attached to substrate*. This curious fact can be churned over in the mind for decades on end. The essential human thermodynamic study of chemical reaction life assumes that social systems of human molecules constitute statistical thermodynamic systems according to which the laws and principles of quantum chemistry and chemical thermodynamics apply. Fields of study in modern human thermodynamics include: psychodynamics, political thermodynamics, hierarchical thermodynamics, social thermodynamics, thermoeconomics, and cessation thermodynamics, among others.

10 – Goethe's Affinities:

"Love is that force which draws affinities together and through its power of cohesion welds them as one."

Peter Clarke, *The Power and Science of Love* (1927)

Human chemistry is the study of reactions between people or in a more general sense the study and analysis of human evolution life from a chemical reaction point of view. The founder of this new science is German writer, scientist, and polymath Johann von Goethe who in 1809, at the age of sixty, after studying the laws and principles of chemistry for a period of forty-one years, scripted the magnificent novella *Elective Affinities*, a scientific treatise on the chemical origin of love.[1]

The seed for the theoretical structure of this novella was the first law of affinity as stated in 1718 by French physician and chemist Étienne Geoffroy, that 'whenever two substances are united that have a disposition to combine and a third is added that has a greater affinity with one of them, these two will unite, and drive out the other.' To expound on this law, Geoffroy made a sixteen-column, eight-row, affinity table containing twenty-four reacting species, showing specifically what affinity reactions would occur between various combinations of reactants.



Three putti studying Geoffroy's 1718 affinity table.[2]

In 1756, Scottish physician and chemist William Cullen began utilizing Geoffroy's affinity table in lectures wherein he pioneered the use of chemical reaction diagrams by using reaction arrows '→' and bonding brackets '{' to show the mechanistic steps in each elective affinity reaction. In the 1770s, Swedish naturalist Carolus Linnaeus, who had recently developed a Latin binomial classification scheme for plant species, urged his compatriot Torbern Bergman, a professor of chemistry at Uppsala, to apply these new methods to the classification of chemical substances, which could likewise

be viewed as species.[3] In 1775 Bergman, in turn, utilized Geoffroy's affinity table, Cullen's reaction schemas, and Linnaeus' classification suggestion to script the first ever chemistry textbook on the topic of 'elective attractions'. The center piece of Bergman's book, entitled *Dissertation on Elective Attractions*, is a fifty-column, fifty-row, chemical affinity table, the largest ever assembled, showing thousands of possible chemical reactions in schematic form between various chemical species, such as, for example, the famous 'double elective affinity' (double displacement reaction), where two chemical units, *AB* and *CD*, exchange or displace partners to form two new evolved species *AC* and *BD*. In this manner, Bergman was the first dominant chemist to use basic letters to represent the various reactant species, e.g. single species: *A, B, C,* etc., or combined species: *AB, AC, AD,* etc., in place of the more confusing older alchemical symbol nomenclature. Thirty-four years later, Bergman's table and affinity laws formed the central backdrop and central story-line of Goethe's novella.

In 1809, Goethe put an advertisement in a literary periodical describing his new novella *Elective Affinities*, a look at human life, particularly romantic life, from the viewpoint of chemistry. Writing in the third person, he surmises that the author must have been led to his strange title through his continuing work in the physical sciences where, he says, we often make use of comparisons drawn from the world of human behavior so that things which are essentially remote from us may be brought a little nearer; and, in the novel, he continues, in a case concerning morality, doubtless the author was seeking to trace an expression used as an analogy in chemistry back to its origin in the life of the human spirit. 'Elective affinities' then, belonging properly in the world of chemistry but deriving from a world of choice and inclination, is returned to that world as a note on or as means of understanding the novel's human events.[4] The advertisement concludes with a general remark, the essence of which is, that 'there is after all only one nature'.

In *Elective Affinities*, Goethe situates the decisive acts of human volition, life, love, death, marriage, and morality, in story form, against the basic laws and science of chemistry. These laws, during the 18th and 19th centuries, consisted of the laws of affinity, which numbered up to ten depending on which chemist was sourced. Goethe's intention was to examine the very real possibility that the process of human love and the choices made therein actuate in accordance with the laws of chemistry just as do the reaction lives of small chemical species. In particular, a year before publication Goethe told his friend Riemer that 'his idea for the new novella was to portray social relationships and their conflicts symbolically', i.e. *a, b, ac, ad, abd, abcd,* etc., and furthermore, according to Goethe, 'the *moral symbols* used in the natural sciences were the elective affinities discovered and employed by the great Bergman.'[5] In other words, what is moral or amoral, in Goethe's view, is a point of view inherent in the laws chemistry according to which species react.

Goethe's *Elective Affinities* is a landmark both in the history of the novel and relations between science and literature.[6] This particular novella is one of the most densely woven and enigmatic works in his oeuvre. It was anticipated with more excitement by readers than any of his other works and, except for *Werther* and *Faust*, has inspired more investigations and debate as to its meaning, both at the time of its first publication and since.[7] Goethe himself stated that, although he wrote the book for 'little girls', to be understood properly, it needs to be read three times; others have stated that it needs to be read five times and that on each pass new hidden gems are found.[8] German novelist Thomas Mann, winner of the 1929 Nobel Prize in Literature, for instance, read it five times while composing *Death in Venice*.

Goethe's depiction of the interaction of science and human relationships sets a high standard for subsequent literary engagements with science. Its central theme is human desire represented as an indescribable, almost magical force of attraction that overcomes social and moral bonds. By exploring this theme through contemporary chemical theories of affinity, Goethe establishes a link between the scientifically described chemical world and the realm of human desires, setting in motion a debate about the role of science in our lives that remains fervent to this day.[9]

The elaborate concept of chemical affinities, found in the work's title, refers to the unpredictable separations and realignments that may result when new personal encounters disturb an existing equilibrium.[7] In modern terms, the backdrop of the novella is where the human reactions takes place. Throughout the novella, Goethe introduces a new player or players (reactants) into the reacting system, chapter-by-chapter, in such a manner that each reaction system is set out-of-equilibrium, and as such they (or the system) subsequently begin to evolve rapidly.

The measure as to how far an earth-bound chemically reactive system is from equilibrium is the change in the Gibbs free energy, i.e. the availability of useful or productive work energy of the system, plotted out against the extent (progress) of the reaction. When a chemical reaction is far from equilibrium or suddenly sparked or displaced out of equilibrium, such as a hydrocarbon combustion reaction in a steam engine or a human romantic reaction in society, much useful work can theoretically be obtained; this is a major discussion point in the novella. There is a constant focus on each person's energy level and work output as the book progresses. Moreover, each chapter depicts a reoccurring contrast between the usefulness or functionality of each character, during the various stages of a reaction, as well as when the reaction conditions are changed, e.g. when one is in the initial stages of love, mid-love, stale-love, or post-stage love, etc., as contrasted with that of a person spurned by love or not in love.

Likewise, the functional energy work-level, which seems to be a desired state of life flow, when optimized, per social class, is major discussion point in the novella. The productivity or work aspects of homeless, working class, middle class, town people, upper class, socialites, servants, laborers, etc., and the seeming happiness or

contentment level correlating with each group and the amount of work activity per group is examined in detail. The central theme revolves around the impulse, need, or proclivity to work in a manner suited to ones desires.

The novella itself is situated around a multi-acre estate with ponds, rivers, trails, houses, a cemetery, a church, and other places all near to a small village. The estate and the surrounding land is the reaction vessel. In other words, the estate is the reaction container or reaction substrate on which, according to Goethe, the human chemical species react according to their natural chemical affinities. The first thing the characters do in the novella, is to survey the area with a compass and to transfer the heights and features of the land to a functional map (affinity map) using various washing techniques, shades, and colors to help distinguish the subtleties and contours of the land. The purpose of this map, according to Goethe, is to 'have a chance to discuss the estate and the things one might now, having had an overview, do with it more easily than when one's *experiments with nature* were isolated, haphazard, and one the basis of only casual impressions.' This estate mapping would be akin to a free energy map, in modern terms.

Throughout the novella, then, various combinations (two's, three's, four's, etc.) of reactants (people) are brought onto the land of the estate (into the reacting system) while others (such as the servants) come, go, or may stay throughout, giving fuel to the various reaction processes, mechanisms, exchanges, and interactions mediated out of each unique situation, with the moral subtleties and fine points of life debated along the way. Goethe's main characters are Eduard and Charlotte, an aristocratic couple both in their second marriage, enjoying an idyllic but semi-dull life on the grounds of their rural estate, who invite the Captain, Eduard's childhood friend, and Ottilie, the beautiful, orphaned, coming-of-age daughter of Charlotte's deceased best-friend to live with them. The decision to invite Ottilie and the Captain is described as an 'experiment' and this is exactly what it is. The house and its surrounding gardens are described as 'a chemical retort in which the human elements are brought together for the reader to observe the resulting reaction.'[6]

The explosive reactions that occur are not the ones that were expected. Despite their seemingly happy marriage, Eduard falls passionately in love with Ottilie and Charlotte with the Captain.[6] The central question throughout the story is can the powerful social bonds of marriage compete against the indescribable forces of attraction that grips these four characters? Moreover, and most importantly, which of these competing forces or obligatory passions is the more correct one to follow from a moral standpoint? In other words, is it immoral to divorce? Or, technically, is a chemical displacement reaction immoral?

In the affinity chemistry of Goethe's time, if a species *A* united to a species *B*, in the form of an *AB* complex, similar to a marriage, were together introduced to third species *C*, such that *A* had greater affinity for *C* than for *B*, a chemical rearrangement reaction would proceed such that *A* would inevitably 'elect' to unite with *C* while

simultaneously detaching from *A*. This would be called a *single elective affinity*. In addition, and most importantly, from a chemical point of view, there would be no morality, i.e. right or wrong, attached to this process; it would simple be a result or chemical consequence of the inherent quantum electromagnetic composition and characteristics of each species in relation to the energetic constraints imposed on the system. In short, the reaction would be a direct consequence of the fact that each chemical species has unique and favored stability tendencies towards other nearby species. Likewise, if an attached species *AB* was introduced to a second united species *CD*, then rearrangements in bonded partners could result based on multiple affinity tendencies or preferences. Such a reaction process would be called a *double elective affinity*. The premise of an approximate human double elective affinity is what forms the central storyline of Goethe's novella and in the famous 'chapter four' is where the mechanism of the main human reaction is explained, in detail, using Bergman's symbols, formulas, and laws.

In short, Goethe used Bergman's 1775 affinity chemistry textbook and its basic reactions as guidelines to understand life and its affairs from a passionate view. To do this was no ordinary feat. Goethe, however, with one of the world's highest-ever estimated IQs of 210, was a voracious student of almost every subject, from science, literature, and legal affairs to poetry and art. Goethe, together with Italian Leonardo da Vinci, are considered the prime examples of what defines a 'polymath', namely a person of great and varied learning. Goethe, according to *The Reader's Companion to World literature*, for instance, 'comes as close to disserving the title of universal genius as any man who ever lived'. British novelist George Eliot, known for her literary realism and psychological perspicacity, defined Goethe as 'last true polymath to walk the earth'.

Goethe's biography is a long and illustrious one similar to that of the great Polish astronomer Nicolas Copernicus, founder of the heliocentric model of the solar system. Specifically, both were lawyers, scientists, polymaths, governors, and political figures, among other occupations and pastimes.[10] Moreover, similar to how Copernicus showed that the earth is not the center of the universe, Goethe, in a way, showed that human reaction life is not the central process of the universe. Both scientists, helped to move us correctly away from the anthropocentric point of view.

Goethe was born in Frankfurt Germany in 1749, and although he is generally known as writer, he interestingly began his studies in the science of chemistry at the age of nineteen, then scripted *Elective Affinities* at the age of sixty, and throughout his active life published over fourteen volumes on various subjects in science.[11] The theoretical foundation of the Goethe's theory of human affinities was based firstly on Geoffroy's original affinity table of 1718, but also primarily on the later works of French chemist Pierre Macquer, *Elemens de Chymie Theorique* (1749), Swedish chemist Torbern Bergman, *Dissertation on Elective Attractions* (1775), and French chemist Claude Berthollet, *Essai de Statique Chimique* (1803).[12] Other possible

chemists whose affinity theories likely had an indirect influence in Goethe's work include: Heinrich Tabor (1782), Johann Gehler (1787), Johann Fischer (1798), and Johann Gottling (1792).[12]

Among the list of affinity chemists, Bergman's work was by far the greatest and from an historical standpoint marked the height of the science of affinity chemistry. Affinity chemistry, during these early centuries, was as intellectually prestigious as chemical thermodynamics and quantum chemistry are now. The latter two, over the last two centuries, in fact, have slowly replaced and so to say updated the former. The centerpiece of Bergman's dissertation consisted of a 50-column, 50-row affinity table able to predict the results or outcomes of several thousand chemical reactions between various species based on affinity tendencies. In his dissertation, Bergman also, using Cullen's reaction diagrams, drew out sixty-four reaction schemas showing which bonds broke and formed during the course of specific reactions. These diagrams and tables provided Goethe with the theoretical stimulation to script his novella. The theory of chemical affinity, however, began long before Bergman.

Affinity theories: 450BC - 1686

In the history of chemistry, the chemical affinity era spans two-millennium. It began with Greek philosopher Empedocles' c. 450 BC theory of attracting (affinity) and repelling (antipathy) forces and ended with the 1920 Nobel Prize in chemistry, being awarded to German chemist Walther Nernst for his work in completing the long-standing goal of calculating the chemical affinities of substances from free energy data, followed by the 1923 publication of *Thermodynamics and the Free Energy of Chemical Substances*, by Gilbert Lewis and Merle Randall, where free energy tables were functionally employed to tackle the 'great problem of chemical affinity'.[13] In the years following Lewis and Randall's publication, the term affinity was replaced by the term free energy in much of the English speaking world.[14]

Subsequently, prior to Goethe's 1809 *Elective Affinity* publication, various pseudo chemical affinity speculations, theories, and analogies were used to explain how and why people fall in and out of love. The term 'affinity', was an elusive word used throughout history in reference to that force which causes chemical changes or reactions.[15] A broad definition of chemical affinity is that whereby substances enter into combination or resist decomposition.[16] The exact origin of the term 'elective affinity', however, according to historians, is difficult to pin down.

In about 3000 BC, the ancient Egyptians had already defined the word love as well as produced the first chemists.[17] The hieroglyphic word for love, in alternative forms, consists of a hoe, a bird, a bun, a mouth, a man with a hand in his mouth (meaning 'a long desire') or two feathers the Egyptian word for *phungwa-phungwa* (meaning 'wanting', but said double or twice as much):[18]



Egyptian hieroglyphics for the word: *love*

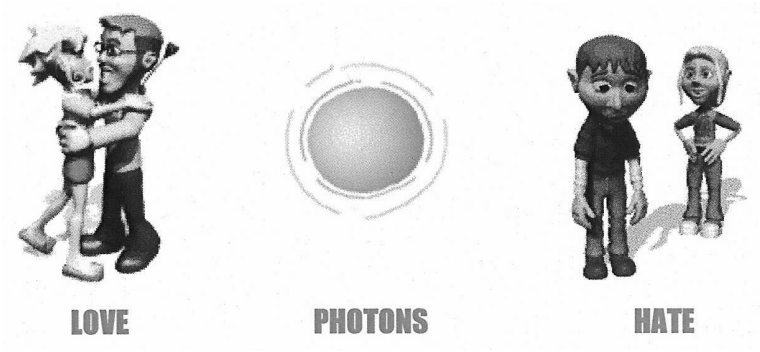
In the years to follow, the word for love grammatically evolved into the Old English *lufu* or *luvu,* which means 'pleasing'. In this manner, the word love characterizes those human processes or situations which are most wanting and pleasing to the desires. The nature of love, and its effects on people, during these early years, was often spoken of in terms of euphemistic metaphors. Egyptologists, for example, have discovered fifty-five anonymous love poems, on papyri and vases, dating back to about 1300 BC. In one poem, *Pleasant Songs of the Sweetheart Who Meets You in the Fields*, we find a women hunting birds while thinking about her loved one:[19]

How wonderful to go to the fields when one's heart is consumed by love!
The goose cries out, the goose that snatched the bait and was trapped.
Your love distracts me and I could not keep it.
I will fold the nets, but what can I tell mother
When I return each day without birds?
I will say I failed to set my nets,
Because the nets of your love have trapped me.

In this poem, a woman inherently uses metaphors to speak about chemical bonds, i.e. 'the nets of your love have trapped me'. She also speaks metaphorically about the transition state of a chemical reaction, i.e. she has to upset or rearrange the old bonds with her mother due to the transition bonding arrangements with her new love; and finds it difficult to work, signifying the fact that those newly in love, in the transition state, are typically not the most effective or productive workers. Lastly, her 'heart is consumed by love' which essentially describes the heated energetics associated with the early transition state or phase of the typical human chemical reaction. This is analogous to the initial stages in a steam engine combustion reaction, where the reactants are 'consumed' in the process, where specifically hydrocarbon molecules react, heat is given off, and useful work is produced. Moreover, she says the goose took the bait and is trapped, meaning that she gave into her feelings of passion and compelling attraction and is now part of a reaction over which she has no control.

One of the earliest recorded pseudo chemical theories was outlined in the fifth century BC by Greek philosopher Empedocles who related the mixing of social groups to the chemical solubility of liquids by stating that 'people who love each other mix like water and wine; people who hate each other segregate like water and

oil.' Empedocles insisted that the two ruling passions of human life, love and hate, are the two ruling principles which pervade and rule the whole universe:



Empedocles was also the first to formulate a 'standard model' of physics.[20] He asserted that all things are composed of four primal elements: earth, air, fire, and water. Moreover, two active and opposing forces, love and hate, or *affinity* and *antipathy*, act upon these elements, combining and separating them into infinitely varied forms.[21] These opposite forces accounted for the attraction and separation of different forms of matter.[22] In short, Empedocles' postulated the existence of a force called *philia* (love) to explain the attraction of different forms of matter and a force called *neikos* (strife) to account for their separation.

In modern terms, there are four fundamental forces in existence, i.e. strong nuclear, weak nuclear, electromagnetic, and gravitational force, whereby attraction-to-repulsion ratios, resulting from field particle exchange, function decisively to account for the ubiquitous phenomenon of bonding in the universe. Stable human bonded relationships, as discussed, are typically held together by a 5-to-1 stability ratio of attraction-to-repulsion, wherein the force is the electromagnetic force and in which the carrier of the force is the photon.[23] The majority of photons that drive all human reactions come from the sun in the form of gamma rays.

In c. 390 BC, Plato built on Empedocles' conception of *philia* (attractive force) and *neikos* (repulsive force) by postulating the *first law of affinity* that 'likes tend toward likes' (likes attract), e.g. earth tends towards earth and water tends towards water, etc. This was sometimes called the Platonic law of affinity. In modern terms, this is often parodied as one of the fabled 'laws of attraction', whereby, for example, people similar in age, views, libido, intellect, activity level, socioeconomic status, or education, etc., are said to match well. Related to this, is the other modern law of attraction, the famous 'opposites attract', championed in the 1950s by sociologist Robert Winch, arguing that people are attracted to those whose needs conversely match their own.[24] Someone who is weak in social situations, for instance, will be attracted to someone strong in social situations, thus forming a complementary pair in that respect. In physical terms, likewise, someone with chicken-legs, for instance, will be attracting to someone who has exceptional looking legs.

One of the first to make a connection between love and the electromagnetic force was the Andalusian poet and philosopher *Ibn Hazm*, who in his classic 1022 book *The Ring of the Dove* wrote that 'the union of souls is a thousand times more beautiful than that of bodies'. His attitude was deeply platonic as well as Muslim, especially when he spoke of the need to become one with the beloved.[19] The idea of becoming one with a beloved person, from a chemical point of view, signifies the conception that two people in love are actually two molecules bonded as one. Chemically, to clarify, when two human molecules bond, i.e. create a union, they become by definition a dihumanide molecule, i.e. two humans bonded through an electromagnetic attachment as one unit. In this direction, Hazm states 'the lover's soul is ever-seeking for the other, striving after it, searching it out, yearning to encounter it again, drawing it to itself it might be as a magnet draws the iron.' In excellent style, Hazm makes a direct connection between the electromagnetic force and the force of love, which he assumes to be the same.

The name *affinitas* was first used in the sense of chemical relation by German philosopher Albertus Magnus in the year 1250 to qualify the combinations of bodies. Magnus use the term affinity, for example, to define the cause of combination of sulfur with silver and other metals. Magnus employed phrases such as 'sulphur destroys the metals because of its natural affinity to them'.[25] In his *Book of the Marvels of the World*, Magnus outlined four principles related to affinity. The first principle of affinity is that likes attract to likes, meaning that an attraction between things with similar qualities or virtues exists, stated in general terms, referring to the Aristotelian elements: earth, air, fire, and water. The second affinity principle is that all things have prime, or first, qualities, but can acquire second or third qualities by association. The third affinity principle is that qualities may be innate to a whole species or to individual things. The fourth affinity principle is antagonism where just as all things attract related things with like qualities, they also 'repel' things with opposite qualities.[26] Magnus' affinity theories and works were frequently reprinted well into the 16th century.

In 1620, English scientific philosopher Francis Bacon developed theories on chemical affinity to explain the inherent nature of motion and its causes. Bacon reasoned that 'dispute and friendship are the spurs to motion in nature, and the keys to her works.'[27] Bacon defined chemical affinity as such: 'it is certain that all bodies whatsoever, though they have no sense, yet they have perception; for when one body is applied to another, there is a kind of *election* to embrace that which is agreeable, and to exclude or expel that which is ingrate; and whether the body be alterant or altered, evermore perception precedeth operation; for else all bodies would be like one to another.'[28] This logic, naturally, evolved into a conception of elective attraction or *elective affinity*, defined as 'a favorable inclination to one more than to another' or a process in which 'a substance tends to combine with certain substances in preference to others.'[29]

In 1648, German-Dutch chemist Johann Glauber discussed the fact that 'a body did not have the same inclination to combine with every other'.[30] This led to various attempts to order the elements according to their different inclinations to combine with each other.[31] Glauber used the conception of chemical affinity, in his *Novi Furni Philosophici*, through the use of the common German word *Gemeinschaft* or 'associative tendency', to explain how acids combine with metals or alkalis. He used chemico-anthropomorphic phrases such as 'for sand and its like have great community with the salt of tarter and they love each other very much, so that neither of them willingly parts from the other.'

During this century, chemists would often use anthropomorphic terms to explain why some substances combined with others. Chemists would argue that certain substances love or have sympathy for each other, particularly for the neutralization reactions of the acids and alkalis, or that of other substances being enemies to each other and subduing one another. The mechanical philosophers, who viewed chemical operations to be regulated by fixed mechanical laws, naturally objected to this line of argument.[32] Robert Boyle, in the 1680 edition of the *Sceptical Chymist,* for example, protested against the prevalent accrediting to material substances of the ideas of antipathy and sympathy, or enmity and amity, these qualities being attributes of the human mind and not common to inanimate bodies.[33] To remedy this inherent tension, Isaac Newton proposed the existence of chemical forces.

Affinity theories: 1687 - 1808

In 1680s, the great English physicist and astronomer Isaac Newton developed the mathematical laws and equations that govern the movement of the planets and stars. It soon became apparent to chemists that a similar set of laws may possibly govern the movement of chemical species as they interact with each other through their various natural affinities.

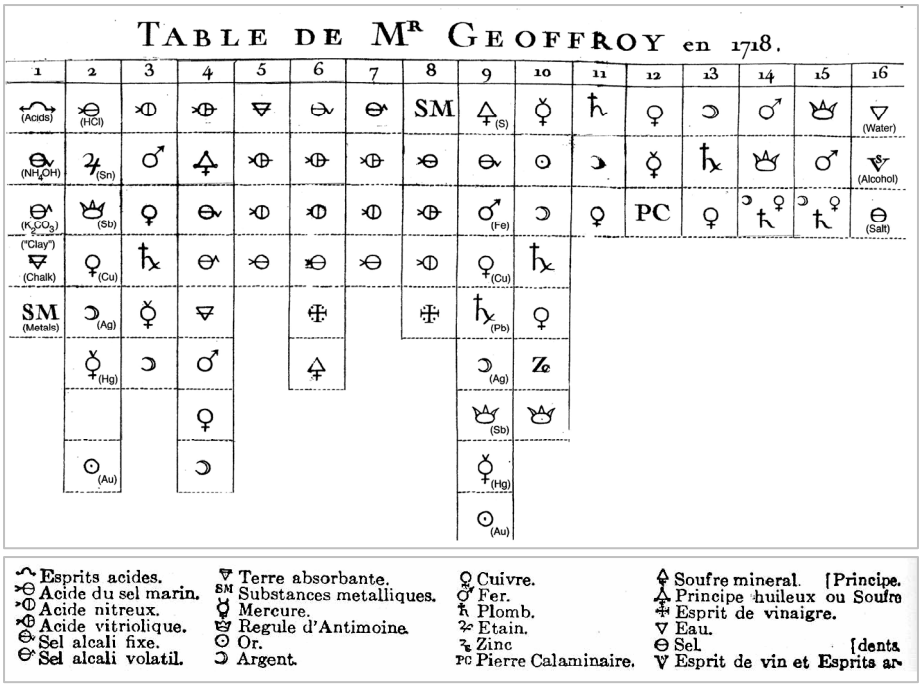
In this manner, to alleviate the issues associated with use of anthropomorphic terms in describing chemical attachments, Newton introduced the conception of a chemical force. In his 1687 *Mathematical Principles of Natural Philosophy* Newton announced his success in discovering the mathematical laws that govern the motion of the celestial bodies according to the force of gravity. In the preface section, however, he notes that those forces, such as physical cohesion and chemical attraction, which govern the motion of the smaller bodies of chemistry, have eluded him. Yet, he is induced by many reasons to suspect that 'they may all depend upon certain *forces* by which the particles of bodies, by some causes hitherto unknown, are either mutually impelled towards each other, and cohere in regular figures, or are repelled and recede from one another.' By defining chemical affinity in terms of 'forces', in this manner, most historians cite Isaac Newton as the main stimulator of affinity chemistry.[16]

Newton's proposal of chemical forces, essentially, then marks the true start date of affinity chemistry. Here after, chemists began searching and theorizing to find these missing forces. Later, Newton's alchemical forces came to be categorized as chemical affinities. The term elective affinity soon began to be used significantly, most likely stemming from Bacon's terminologies. Newton's implicit suggestion that scientists should study chemical 'affinity' became explicit in the celebrated 31st Query of his 1718 *Opticks*: 'we must learn from the phenomena of nature what bodies attract one another, and what are the laws and properties of the attraction.'

In addition, he asks 'have not the small particles of bodies certain powers, virtues, or forces, by which they act at a distance, not only upon the rays of light for reflecting, refracting, and inflecting them, but also upon one another for producing the great part of the phenomena of nature? Newton declares, after noting the fact that all bodies act one upon another by the attractions of gravity, magnetism, and electricity, that it may not be improbable that there may exist other possible forces or that 'there may be more attractive powers than these.' Moreover, Newton uses the word attraction to signify, in a general sense, any force by which bodies tend towards one another, whatsoever the cause. In sum, he suggests the possibility that all chemical properties and reactions my be explained by the attractive powers of the particles of which matter is assumed to consist, as well as by their size, arrangement, polarity, hardness and other characteristics.[32]

In response to these grand statements, that very same year, French physician and chemist Étienne-François Geoffroy took Newton up on his affinity challenge by arranging a twenty-four essential substances, including acids and bases, in a table of affinities, or *table of rapports* as he called them, in an paper entitled 'Table of the Different Relations Observed in Chemistry between Different Substances'. In short, whereas Newton had first pointed out that chemical substances could be arranged consistently in order of the strength of their attraction for certain other substances, Geoffroy went a step further by tabulated these various attractive and repulsive tendencies. Some historians have gone so far as to signify Geoffroy's affinity table as being the cause of the chemical revolution.[34]

In this presentation, Geoffroy carefully avoided the use of the terms 'attraction' with its Newtonian connotations, and 'affinity', which could invoke alchemical notions of occult sympathies.[35] By referring instead to rapports (relationships), he tried to maintain a certain neutrality on the theoretical issues, but suspicions that Geoffroy was covertly representing the Newtonian outlook prevailed.[36] After completing his medical degree in 1704, Geoffroy, who had originally studied under Dutch chemist Wilhelm Homberg, soon developed a keen interest in the works of Newton. Having received a copy of the 1704 English edition of Newton's *Opticks*, for example, Geoffroy immediately translated it into French.[37] Owing to these stimulations, Geoffroy was driven to publish his famous 1718 affinity table, shown below:



To deconstruct this table further, at the head of each column is a header species with which all species below can combine or have a rapport with. The latter are so placed such that any higher species replaces all others lower in the column from their compounds with that at the head of the table. In other words, the species at the head of the table can potentially react with any species below it. All the species below the header species are ranked by chemical affinity preferences relative to the top species, with a higher rank corresponding to a higher affinity tendency. The species at the bottom of each column, for instance, have the least amount of affinity for the header species. If the bottom species is in a weakly bonded relationship with the header species, any species above it can potentially displace it from its attached partner.

Goethe, in turn, viewed Geoffroy's affinity table as though it were filled with different chemically reactive people with varying amounts of bonding affinity for one another. Each header species, for example, would represent a different man or women. The species below each person would be the various reactants with which that specific header person could potentially react with, arranged according to unique chemical affinity preferences. Goethe believed these relations to exist in human life, owing to the fact that the logic of this affinity table chemistry was based on a well established law of nature. Geoffroy, as mentioned, stated his *first law of affinity* as such:

> "Whenever two substances are united that have a disposition to combine and a third is added that has a greater affinity with one of them, these two will unite, and drive out the other."

This law was built on observations that had previously been made by scientists such as Geber (c.750), Paracelsus (c.1520), Bacon (1620), and Glauber (1648).[12] In theory, this law could be used to work out the proximate affinity relations between all known substances. If, for example, a body *E* is driven out of the combination *AE* by *D*, *D* is driven out by *C*, and *C* by *B*, then *D* has a stronger affinity for *A* than *E*, *C* has a stronger one than *D*, and *B* has a stronger one than *C*. These affinity displacement reactions are shown below:

$$AE + D \rightarrow AD + E \qquad [10.1]$$

$$AD + C \rightarrow AC + D \qquad [10.2]$$

$$AC + B \rightarrow AB + C \qquad [10.3]$$

The order of affinities, according to these reactions, is then *ABCDE*. These types of reactions were used to construct Geoffroy's affinity table and were later used as the basic definition in Bergman's chapter on single elective attractions.[38]

Although these displacement reactions, and a table associated with them, seem quite obvious from a modern-day perspective, in the early 18th century the opposite was true. Geoffroy's table, as historians agree, was completely original.[32] After this publication and over the next thirty-years, aside from Grosse's affinity table of 1730, which was merely a reprint, no new tables were produced. The following synopsis, in commenting on the idea of affinity tables, from the *Histoire del' Academie Royale des Sciences*, gives an idea of the viewpoint during these years: 'that a body which is united to another, for instance a solvent which has penetrated a metal, should leave it to go and unite with another which is presented to it, is a thing of which the possibility would not have been guessed by the most subtle of philosophers, and of which the explanation is still today not too easy for them.'[39]

In continuation, 'one imagines first that the second metal fits the solvent better than the former which has been abandoned by it, but what principle of action can one conceive in this better fit? It is here that sympathies and attractions would come very much to the point, if they meant anything. But in the end, leaving as an unknown that which is unknown, and keeping to certain facts, all the experiments of chemistry prove that a particular body has more disposition to unite with one body than another, and that this disposition has different degrees.' Moreover, in a style almost

identical to that which Gibbs would use, who in 1873 stated 'these results show us … how *we might **foresee** whether two given states of a substance*… can or cannot exist in contact' when discussing his formulation of free energy, we find 'this table becomes sort of prophetic, for if substances are mixed together, *it can **foretell** the effect and the result of the mixture*, because one will see from their different relations what ought to be, so to speak, the issue of the combat.' In other words, Geoffroy's affinity table allowed its users to predict the course of a reaction just as Gibbs' free energy tables allow modern chemists to predict the course of reactions presently; the latter is a scientific evolution of the former.[40] In human chemistry, this translates to the equivalent effect that chemical thermodynamic measurements, compiled in the form of human molecular free energy tables, will enable future human chemists *to **predict** the course* (feasibility) *of human chemical reactions*, particularly romantic ones, from among a mixture of potential selected mates (desired marriage partners).

In 1749, French chemist Pierre Macquer, in his chemistry textbook *Elemens de Chymie Theorique*, built on Geoffroy's affinity tables by devoting an entire chapter to the subject of chemical affinities.[41] In this book he states 'all the experiments which have been hitherto carried out, and those which are still being daily performed, concur in proving that between different bodies, whether principles or compounds, there is an agreement, relation, affinity or attraction, which disposes certain bodies to unite with one another, while with others they are unable to contract any union: it is this effect, whatever be its cause, which will help us to give a reason for all the phenomena furnished by chemistry, and to tie them together.'

This was the first chemistry textbook to use 'affinity' as a conceptual tool to unify the whole of chemistry.[12] All the phenomena that appear in chemistry, according to Macquer, are based on the affinities which exist between different substances. In the second chapter, Macquer lists six 'fundamental truths' concerning the rapport, affinity, or attraction that explained the selectivity in chemical action. These fundamental truths, as listed below, were an early formulation of the six laws or principles of affinity:

First truth – if to a compound of two substances, a third substance were presented which had a greater rapport for one of the two in the union, the third substance would decompose the compound and form a new union.

Second truth – a third substance could potentially join a compound of two substances without decomposing it.

Third truth – a substance that could not decompose the compound by itself could succeed nevertheless when it was combined to another via a double decomposition process.

Fourth truth – when two or more substances are united they lose some of their properties.

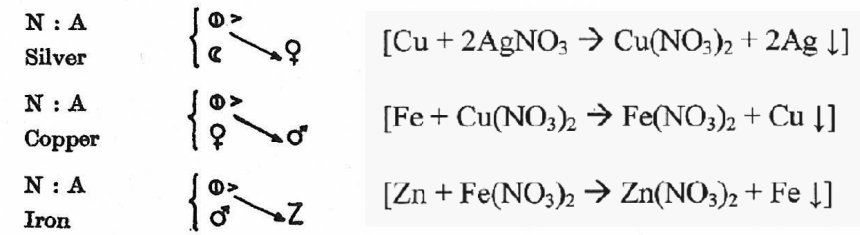
Fifth truth – similar substances have an affinity for one another and are thus disposed to join, e.g. water to water, earth to earth, etc.

Sixth truth – simpler substances have more sensible and considerable affinities and are thus more difficult to separate.

The first and fifth truths here are Geoffroy's and Plato's affinity laws, respectively. Macquer, similar to Bergman, with whom he corresponded with frequently, also was one of the first to adopt a Linnaean system of classification. He presented these as seven theses in 1753 and then later formulating a topology of seven types of affinity in his 1766 *Dictionnaire de chymie*. This reaction typology provided Goethe with a partial framework for the chemical theory in his novella.

In 1757, Scottish physician and chemist William Cullen began to use Geoffroy's affinity table in lectures at the University of Aberdeen.[42] To help in explaining to his students the idea of 'single elective attractions' (single displacement reactions) and 'double elective attractions' (double displacement reactions), Cullen pioneered the use of reaction arrows '→' or 'darts', as he called them, drawn diagonally to represent the affinity tendencies of the individual species in the reaction. In addition, he introduced the conception of using brackets '{' to represent a bonded association.

In Cullen's lecture notes, a core example used is the list of species in the third column of Geoffroy's affinity table. At the head of the third column, i.e. row-one, column-three (R1:C3), is nitric acid HNO_3 which Cullen labels as N : A. The relative affinities of nitric acid, according to Geoffroy, are in the order: iron ♂, copper ♀, lead ♄, mercury (R5:C3), and silver (R6:C3). Therefore, iron would displace copper from a solution of copper in nitrous acid and would similarly displace lead, mercury, and silver from their solutions of nitrous salt. Using the conception of affinity arrows and bonding brackets, Cullen used diagrams in his lectures to represent these individual reactions steps of single elective affinities or single displacement reactions, such as shown below, in the middle diagram, with the modern day chemical reaction equivalent adjacent, to the right:



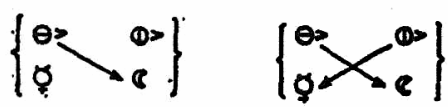
Cullen's single elective affinity reactions diagrams (center)

In the last reaction, Cullen shows zinc *Z* displacing iron ♂ from a solution of iron in nitrous acid. To explain these reaction diagrams, Cullen states that 'the upper character is the nitrous acid and below it is silver; by the mark '{' I mean them

united to one another; opposite them is copper, the dart between them expresses the *elective attraction*. When I put a dart with the tail to one substance and the point to another, I mean that the substance to which the tail is directed unites with the one to which the point is directed more strongly than it does with the one united to it in the crotchet; then I would say that the nitrous acid attracts copper more strongly than silver to which it is connected, and it attracts iron more strongly than copper and zinc more strongly than iron.'

Goethe, in his novella, applied this conception of 'elective attraction' between reactive human species through the use of metaphors and verbal descriptions. When discussing the effect of Eduard and Ottilie on each other, for example: 'as before, they exerted an indescribable, almost magical power of attraction over each other. They lived under the same roof; but even when not thinking of each other, preoccupied by other things, pulled hither and thither by society, they drew near to each other. If they were in the same room, it did not take long and they were standing, sitting down beside each other … Yes, if you had held one of them fast at one end of the house, the other would, by and by, and wholly without intent, have moved to him.'[43]

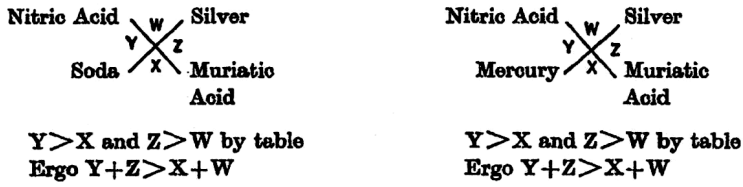
Next, Cullen introduces to the more complicated double elective attraction. He states that 'from the tables of elective attractions of Mr. Geoffroy, we may know whether or not a double elective attraction may be applied; by looking at the column of marine acid (hydrochloric acid [HCl], R1:C2) in his table we find whether the marine acid has any relation with regard to the silver (R5:C2). I find silver stands above quicksilver (mercury [Hg], R6:C2) and I draw a dart', as shown below (left):



Cullen's single (left) and double (right) affinity reaction diagrams

Next Cullen states that 'by looking at the column of nitrous acid, I find quicksilver (R5:C3) stands above silver (R6:C3); then I draw a dart from the acid to it.' This is diagramed above on the right. This reaction diagram is the first case of a double elective attraction used in Cullen's lecture notes and possibly the first ever mention in science.[42]

Cullen also utilized two-way arrows to indicate the different possible ways in which the affinity tables could be read in order to make reaction diagrams. In addition, in 1758 Cullen began using *lever diagrams*, consisting of a saltire or cross-wise shaped diagonal lines, with the forces of each affinity, assigned to the letter W, X, Y, and Z, listed at each joining apex. With these, he employed a sort of rudimentary affinity algebra to calculate and to quantify the forces in various affinity reactions:



Cullen's 1758 affinity lever diagrams

This algebra of the forces of affinity may have had their partial origin from the ideas of English physician Andrew Plummer, a professor of chemistry at the University of Edinburgh from 1726 to 1755. Cullen was Plummer's associate and later became his successor. Plummer interpreted chemical reactions as the result of competition between attractive and repulsive forces.[44] Cullen naturally incorporated these views and later Cullen's pupil Scottish thermochemist Joseph Black, one the founders of thermochemistry, further expanded and elaborated on these views in his lectures as a professor of chemistry at Edinburgh in the 1770s and 80s. Macquer in his famous *Dictionary of Chemistry* also gives the suggestion that chemical combination is the result of a superiority of one set of competing forces over another, but gives no diagram.[45]

During these formative years, certain inherent difficulties concerning the theory behind the use of affinity tables were beginning to appear. Namely, the possibility of reversible reactions, second that three or more reactants might involve 'competing affinities' became apparent, and third that affinities in general might vary according to the effects of both heat and varying concentrations. All of these were viewed as possible complicating factors in the calculation of affinities. Cullen and Black, for instance, both had mentioned the possibility that heat may have a significantly effect on affinities. In 1782, Antoine Lavoisier pointed out that there should ideally be a different affinity table for each degree of the thermometer.

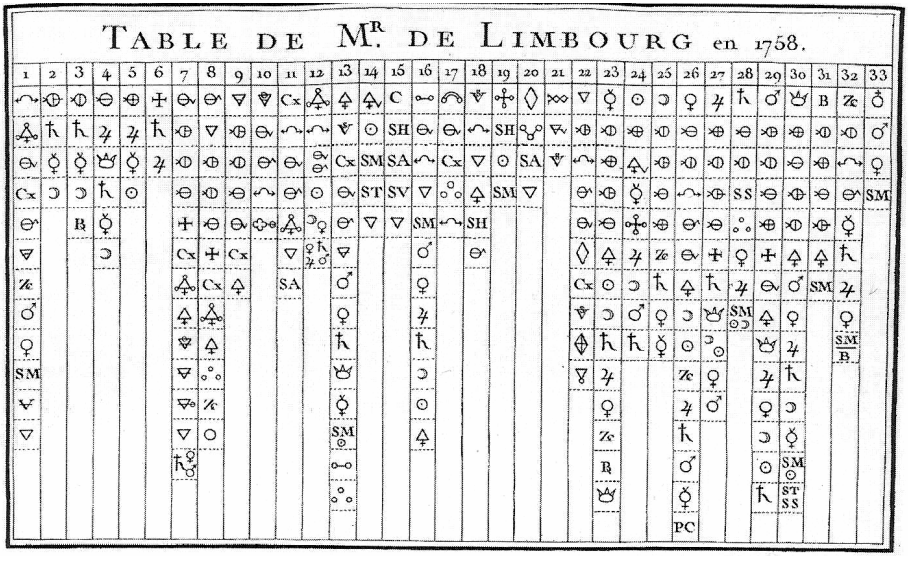
In modern terms, in which 'free energy' is the true measure of affinity, these difficulties are resolved by the implicit use of temperature T in [4.9], where instead of calculating numerous reaction affinities A at each specific temperature to determine the feasibility of any given reaction, we calculate the change in the Gibbs free energy G per unit mole:

$$G = H - TS \qquad [4.9]$$

Thus, instead of constructing numerous affinity tables at each temperature, we measure a specific enthalpy of formation ΔH_F for each species in a reaction and a specific entropy value, based on a predetermined reference, for each chemical species, at the initial S_I and final state S_F of the reaction, data that can fit on one concise table (as found in all chemistry textbooks), and use basic algebra to find the negative of the free energy change ΔG, which is the measure of affinity.[46]

In continuation with the history of affinity overview, in 1765 French naturalist and mathematician Georges-Louis de Buffon, in his *Histoire Naturelle*, attempted to apply Newton's inverse square law of gravitation to the interactions of small particles in contact.[47] The laws governing affinity, he wrote, are the same as the laws governing very large bodies. When the distances between the bodies are very large, their shape is of almost no importance; but when the distances become very small their 'shape' is extremely important because the distances between the parts of a body are appreciable in comparison. Indeed, in human life, the unique shape of another person, e.g. sexual dimorphic traits, skin tone, fitness, a natural smile vs. a reoccurring frown, etc., as well as the shape of one's movements, e.g. how one reacts to others, or the shape of one's life, etc., are key factors in human affinities. The following year, in molecular terms, this viewpoint was incorporated into Macquer's *Dictionary of Chemistry*.

In the latter half of the 18th century, over a dozen Geoffroy-style affinity tables were published by various chemists.[34] In France, chemical affinity was especially popular. In 1758, for example, the Academy of Rouen offered a prize to any chemist who could 'determine the affinities that are found between the principle mixts, as Geoffroy did, and find a physico-mechanical system of these affinities.' Although no one could satisfy both conditions of the prize stipulation simultaneously, many provided partial answers. The committee eventually divided up the prize between French physician and chemist Jean Philippe de Limbourg and French philosopher and mathematician George Louis Le Sage, for each had only answered half of the question successfully.[48] Le Sage had supplied a mathematical exposition of affinity in line with the concept of gravity; Limbourg had produced an extended 33-column affinity table, as shown below:



Other notable tables include Grosse's 1730, 19-column affinity table, Gellert's 1750, 28-column affinity table, Rudiger's 1756, 15-column affinity table, Spielmann's 1763, 28-column affinity table, Marherr's 1762, 120-column (3-row) affinity table, Demachy's 1769, 20-column affinity table, and De Fourcy's 1773, 36-column affinity table. The majority of tables, to note, are 18-rows or less. In short, affinity chemistry was the pinnacle subject of study in chemistry in the 18th century.

The most famous and largest of these was Bergman's 1775, 50-column affinity table, containing 50-rows of reactant species as found in his textbook *Dissertation on Elective* Attractions.[34] In the 1785 edition, Bergman utilized an even larger 59-row, 50-column, affinity table. In symbol format, this table covers some four sheets of paper on a fold-out map; when the names are listed instead of symbols, the table covers eight sheets of paper on a large fold-out affinity map.[49]

It was Bergman's affinity table and dissertation which influenced Goethe the most. The top half of Bergman's table shows reactions conducted in the 'wet way', i.e. liquid-phase reactions, and the bottom half shows reactions in the 'dry way', i.e. reactions using fire or heat. Bergman technically defined elective affinity as the tendency of chemical species to combine with certain substances or species in preference to others.[50] In a sense, certain chemical species would 'elect' to unite, bond, or chemically react with only certain other select chemical species based on heightened chemical affinities. The calculation of affinities in an *a priori* manner was a primary focus of chemists during these years. In this direction, Bergman's 1785 table was the largest affinity table ever published. Bergman's work became the most famous in the field and gave affinity studies their definitive shape for the next twenty-five years.[12]

The opening sentence of his dissertation outlines this object. He states, as a matter of fact, that 'it is found by experience that all substances in nature, when left to themselves, and placed at the proper distances, have a mutual tendency to come into contact with one another … this tendency has been long distinguished by the name of *attraction*.' In this direction, however, Bergman states that the purpose of his dissertation is not to inquire into the cause of this attraction, but rather to 'know the laws to which it is subject in its operations'. He continues, 'it has been shown by Newton that the great bodies of the universe exert this power directly as their masses and inversely as the square of their distances.'

Next, Bergman defines *contiguous attraction* as 'the tendency to union observed in all neighboring bodies on the surface of the earth'. He states that contiguous attraction affects small particles and scarcely reaches beyond contact. He contrasts this with *remote attraction* as that which extends through space to the great masses of matter. Thus, he concludes that attraction or affinity depends on circumstances; along lines similar to [6.11]. Goethe, similarly, assumed that the laws of contiguous attraction will apply absolutely to human life, being that human beings are 'bodies on the surface of the earth.'

To distinguish between remote and contiguous attraction, Bergman states that in most cases celestial bodies may be defined as 'gravitating points', owing to the vast distances between them. With contiguous bodies, however, the situation depends on their parts, which 'produce a great variation in the effects of attraction'. In Goethe's view, humans are contiguous bodies. In human terms, factors such as averageness, symmetry, youthfulness, body type, body mass index, weight, waist-to-hip ratio, complexion, etc., all produce a great variation in the effects of attraction. Pear, apple, spoon, triangle, or poll shaped female bodies, for example, are less physically attractive, on average, than the most-coveted hourglass shaped bodies.[51]

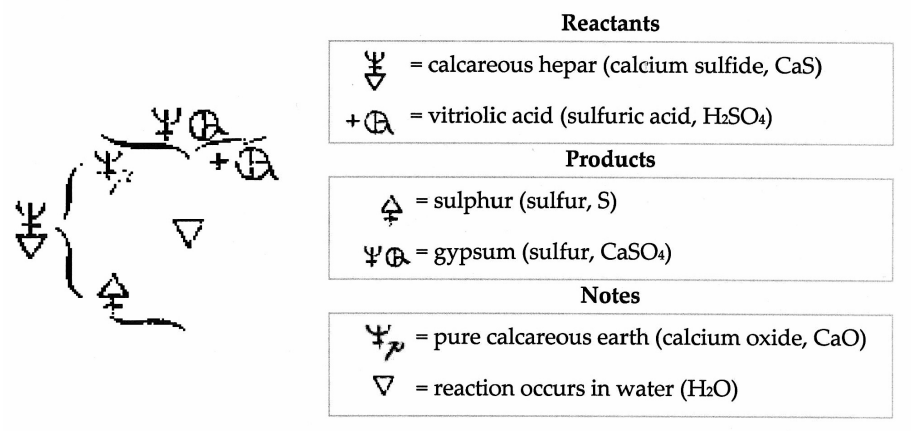
Bergman notes that many scientists, in the last few years, had been creatively attempting to measure attractions between contiguous bodies. French chemist Louis de Morveau, for instance, attempted to obtain measures of affinity by determining the amount of work or force required to remove sheets of various metals from liquid pools of mercury. Likewise, English chemist Richard Kirwan attempted to use the saturation capacity of acids and bases as a representative measure of affinity. Along these lines, Bergman reasons that soon enough affinities would be expressed exactly through the use of numbers. In human molecular terms, measuring affinities is more complicated, but is done when we gauge the unique value of person's looks, grace, beauty, character, intellect, personality, humor, function, etc., each of which can be correlated to values of free energy.

Bergman then defines *single elective attraction* as a reactive union that takes place between three or more substances, to the exclusion of one, and defines *double elective attraction* as double reactive union that takes place between two compounds, each consisting of two proximate principles, which are exchanged in consequence of the mixture. To elaborate further on the conception of single elective attractions, Bergman states his famous affinity example, that later stimulated Goethe to script his theories on human elective affinities, 'suppose *A* to be a substance for which other heterogeneous substances *a, b, c,* etc, have an attraction; suppose, further, *A*, combined with *c* to saturation, (this union I shall call *Ac*), should, upon the addition of *b*, tend to unite with it to the exclusion of *c*, *A* is then said to attract *b* more strongly than *c*, or to have a stronger elective attraction for it; lastly, let the union of *Ab*, on the addition of *a*, be broken, let *b* be rejected, and *a* chosen in its place, it will follow, that *a* exceeds *b* in attractive power, and we shall have a series, *a, b, c*, in respect of efficacy.' In continuation, to clarify his choice of words 'what I here call *attraction*, others denote as *affinity*; I shall employ both terms promiscuously in the sequel, though the latter, being more metaphysical, would seem less proper in philosophy.'

Not only was this the first case of chemist's use of letters to represent chemical species, but also the interesting formalism of an '*Ab* union', an idea quite advanced for its time. It is very easy to see how Goethe correctly interpreted this passage as applying to human relations and affairs, where, for example, the *Ab union* would

represent the prototypical marriage bond, i.e. an 'A≡B union', between a man and a woman. The use of the above passage in Goethe's novella, in his famous chapter four, has been a heated issue of debate and argument for nearly two hundred years now.[52] The central question resides around the dichotomy between human behavior and chemical behavior. Are they one and the same and, if so, do they follow or abide by similar affinity laws?[53]

Included in Bergman's dissertation, is a table of sixty-four reaction schematic diagrams, which exhibit the events of 122 experiments. The first example reaction Bergman steps through is the decomposition of calcareous hepar (calcium sulfide) by vitriolic acid (sulfuric acid), as shown below:


Reactants
= calcareous hepar (calcium sulfide, CaS)
+ = vitriolic acid (sulfuric acid, H2SO4)
Products
= sulphur (sulfur, S)
= gypsum (sulfur, CaSO4)
Notes
= pure calcareous earth (calcium oxide, CaO)
= reaction occurs in water (H2O)

In this chemical reaction, calcium sulfide *CaS* is decomposed by sulfuric acid H_2SO_4 in water to produce elemental sulfur *S* which precipitates (downward half-bracket) and calcium sulfate $CaSO_4$, which also precipitates (down full-bracket). In modern terms, neglecting intermediates, this reaction would be written as:[54]

$$CaS + H_2SO_4 \rightarrow CaSO_4 + S \qquad [10.4]$$

In the middle of these reaction diagrams, Bergman uses the nabla symbol ∇, the alchemical symbol for water, to indicate that the reaction occurs the wet way, i.e. in water, or according to Bergman, 'intimating that the three surrounding bodies freely exercise their attractive powers in it.' In other diagrams, Bergman uses the delta symbol Δ, the alchemical symbol for fire, to indicate reactions which are performed in the dry way. In modern terms, these reaction condition details are typically listed over the reaction arrow, as H_2O or heat, respectively, such as:

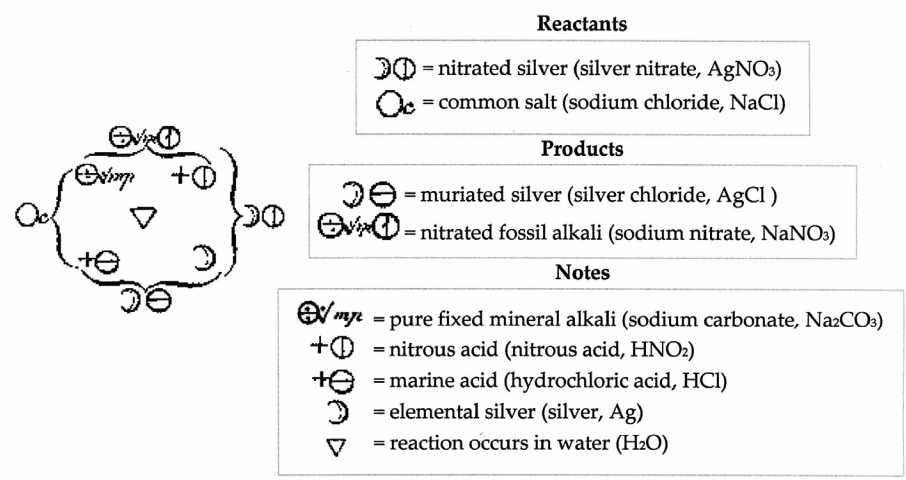
$$A \xrightarrow{H_2O,\Delta} B$$

In addition, Bergman, similar to Cullen, uses brackets '{ or }' to signify a bond or chemical attachment. *Vertical brackets* are used to signify the constituent bonded species, proximate principles, or units comprising a compound. *Horizontal brackets*, similarly, are used to signify the products of the reaction: a downward position indicating the formation of a precipitate or solid product and upward position indicating the formation of a gaseous product or one that remains in the liquid state. The complete horizontal bracket indicates a new combination, whereas the half-bracket signifies, by the direction of its point, whether the substance from which it is drawn remains in the liquid or falls to the bottom as a precipitate. The absence of a horizontal bracket indicates that the original compound remains entire.

The essential purpose of these diagrams, according to Bergman, is so 'that the effect of substances mixed together may appear at one view.' These diagrams, according to chemistry historians, were likely based on those of Cullen and Black.[42] In these diagrams, Bergman avoids anything which might imply a theory about causes or mechanisms, for this would only be mere speculation. Instead of assigning forces to a reaction step, for example, Bergman would assign a phrase such as 'one substance is partitioned between two others'. Goethe, in turn, viewed these diagrams as though they were topographical maps showing the making and breaking of bonds between humans. In the novella, as mentioned, one of the first things the characters do, in chapter three, is to make a topographical reaction map of the land surrounding the estate so to better see their 'experiments with nature'.

Bergman's views on elective affinity mark the pinnacle point in the era of the chemical affinity theories. Antoine Lavoisier, for example, in his 1787 *Elements of Chemistry,* stated that the branch of chemistry that treats affinities is the best calculated part of chemistry in that it is reducible to a completely systematic body of facts. Moreover, according to Lavoisier, 'the science of affinities, or elective attractions, holds the fame place with regard to the other branches of chemistry, as the higher or transcendental geometry does with respect to the simpler and elementary parts.' In modern terms, the science of affinity, as will be discussed shortly, is presently divided between the sciences of chemical thermodynamics and quantum chemistry.[16] Goethe's affinities, now-a-days, would be equivalent to the effect if someone were to use any standard physical chemistry or chemical thermodynamics textbook and use the thermodynamic tables as a basis to script a complex love story in which the various making and breaking of bonds and human reactions followed out according to coupled free energy tendencies and quantum rules.[55]

The next case which Bergman discusses is the so-called 'double attraction' or double elective affinity. When four substances 'exert their action', according to Bergman, a different case, more complicated than when only three substances are concerned, arises. Bergman uses the following reaction schematic as an example:


Reactants
= nitrated silver (silver nitrate, AgNO3)
= common salt (sodium chloride, NaCl)
Products
= muriated silver (silver chloride, AgCl)
= nitrated fossil alkali (sodium nitrate, NaNO3)
Notes
= pure fixed mineral alkali (sodium carbonate, Na2CO3)
= nitrous acid (nitrous acid, HNO2)
= marine acid (hydrochloric acid, HCl)
= elemental silver (silver, Ag)
= reaction occurs in water (H2O)

It shows, according to Bergman, 'the double decomposition of nitrated silver (silver nitrate) and common salt, the new neutral salt, nitrated fossil alkali (sodium nitrate), being dissolved, and the muriated silver (silver chloride) falling down.' In other words, the reaction schematic shows silver nitrate $AgNO_3$ and sodium chloride $NaCl$ decompose each other in water to produce silver chloride $AgCl$, which precipitates (downward bracket), and sodium nitrate $NaNO_3$, which remains in solution (upward bracket). In modern terminology, this reaction would be essentially:

$$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3 \qquad [10.5]$$

In letter format, this would fall under the category of a double displacement reaction:

$$AB + CD \rightarrow AC + BD \qquad [10.6]$$

The central storyline of Goethe's novella is modeled on this reaction [10.6], between four people in a closed human reacting system. In short, Goethe considers *AB* to be a married couple living a happy but dull 'garden-tending' life in a rich country estate. They invite their set of friends *CD* to stay with them. Following their arrival, as each character follows their natural affinities and passions, a double displacement reaction occurs, between *AB* and *CD*, in which, almost simultaneously, *A* falls for *C* and *B* falls for *D*. This is the long and the short of the novella.

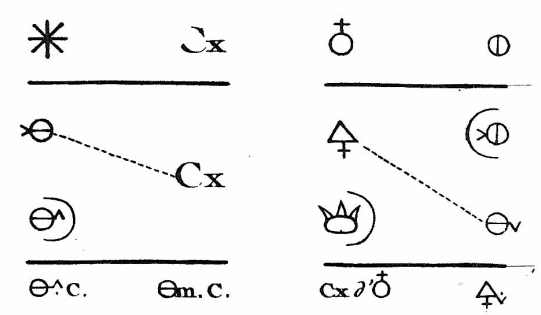
In addition, the manner in which Goethe details the characters use of the land, via drawing maps, making structural changes, e.g. merging three small ponds, and having unique affinities for various topologies, it is likely that Goethe would have viewed these reactions as being akin to a substrate-attracted chemical reaction, in which those characters with the greatest mutual affinities are chemically draw to each other over the reaction surface:

$$\underset{\text{III}}{A} + \underset{\text{III}}{B} \rightarrow \underset{\text{III}\ \text{III}}{A{=}B}$$

Surface map of estate

Goethe also elaborately follows though multiple reaction steps and mechanisms in great verbal detail, not just for the main characters, but for every character in the book, including entire town gatherings.

Moving forward, another example of a Cullen-style or Bergman-style affinity reaction schematic, showing which chemical species would 'elect' to bond with each other, can be found in an 1781 publication of French chemist Jacques Demachy, as shown below:[56]



Demachy's 1781 elective affinity reaction diagrams

In 1787, as mentioned, French chemist Antoine Lavoisier, in his famous *Elements of Chemistry*, was readily using the conception of 'elective affinity' as well as double and triple affinity to explain various chemical reactions and processes. He would state, for example, 'oxygen possesses a stronger elective attraction, or affinity, for phosphorus than for caloric.'[57] Likewise, 'the decomposition of vegetable matter, under high temperature, is produced by the action of double and triple affinities, while the charcoal attracts the oxygen on purpose to form carbonic acid, the caloric attracts the hydrogen, and converts it into hydrogen.' Moreover, using Linnaeus' classification terminologies, 'the distillation of every species of vegetable substance confirms the truth of this theory.'[58] He also includes a table of the combinations of most acids and bases with salifiable bases listed by their order of affinity.[59]

With the introduction of these various affinity tables and reaction diagrams, a new era of chemistry was taking hold. In 1796, for instance, French mathematician Pierre Laplace asserted in his *Exposition du system du monde* that 'all chemical combinations are the result of attractive forces', and that their study was a central task of mathematics and physics. If the 'impossible' could be achieved, he argued, and the form of the molecules constituting matter could be demonstrated, all terrestrial and celestial phenomena would be explained by a single law: 'from the

variety of these forms, one would be able to explain all the varieties of attractive forces, and could bring together every phenomenon of physics and astronomy under a single, general law.' Chemical affinity, for Laplace, was nothing less than the key to the system of the universe.[12]

This general view point, during these years, alludes to a hitherto incomplete chemical theory holding out the promise of a universal physical law that could be transferred to the human sphere.[12] This was this essential aim to which Goethe was striving with his *Elective Affinities* publication. In fact, in a letter to the French diplomat Karl Friedrich, Goethe predicted that the novel's meaning might remain incomprehensible for an extended period of time, only to be rediscovered through multiple rereadings at a later date.[60] One-hundred-and-ninety-eight-years later, it seems, with the new science of human chemistry, its meaning will finally unfold.

Human elective affinities: 1809

In April of 1808, Goethe first made mention of his soon-to-be new novella *Elective Affinities*, an analysis of human life and behavior modeled on the theories, principles, and science of chemical behavior. On a coach journey between Jena and Weimar in May, Goethe recounted a large part of his preliminary novella to his friend Heinrich Meyer. In the months to follow, he composed the final version aloud as was taken down by Goethe's secretary Riemer. In addition, contrary to his general practice, he destroyed all the earlier drafts. By July 30, he had declared his new novella finished. Moreover, prior to this, he had put himself under pressure by allowing printing to begin before the last chapters were written, thus publishing in October 1809. This grand month marks the inception date for the science of human chemistry.

The entire book, in a fascinating manner, is cryptic on all levels and riddled with subtleties. In a letter to his friend, the composer Karl Friedrich Zelter, for example, Goethe wrote that he had not only placed numerous different elements within the text, but that many of these were hidden within it and that past the transparent or non-transparent veils in the novel one may be able to see the 'truly intended Gestalt'.[52] *Gestalt*, by definition, is a structure, configuration, or pattern of physical, biological, or psychological phenomena so integrated as to constitute a functional unit with properties not derivable by summation of its parts.

Prior to the writing of *Elective Affinities*, Goethe had done serious work in most branches of the contemporary sciences, notably in optics, geology, botany, and physiology. He even inspired Charles Darwin in his theory of evolution, with his independent discovery of the human premaxilla jaw bone.[61] In biology, Goethe's theory of plant metamorphosis, for example, stipulated that all plant formations stem from a modification of the leaf.[62] Goethe's first detailed presentation of 'affinity' occurs in his third *Lecture on Anatomy* of 1796.[63] With this broad knowledge base,

and with his background as a lawyer and political figure, the use of scientific, social, and political theory is fortuitously embedded throughout *Elective Affinities*.

It is along these lines that not only are the issues in the novella debatable topics, but so to even is the title, which itself has been a constant source of heated debate and critical confusion, even in the present century; it points to a scientific theory and to a meaning of marriage.[52] The German term 'Wahlverwandtschaften' or *Elective Affinities* originates from a 1782 translation of Bergman's chemical affinity treatise *De attractinibus electives* (Dissertation on Elective Attractions).[64] One reader, for example, might dissect the compound words 'Wahl' meaning 'choice' and 'Verwandtschaft' meaning relatives, and see the translation to mean that we have no choice in who we relate with; others might associate the word with the scientific theory, reasoning that we 'elect' to choose who we affine to.

The title translates the chemical term of an elective attraction and the process which this term designates provides a basic pattern for the plot: a so-called 'double affinity' or double adultery, as Goethe describes it. The special twist in the novella, however, is that the adultery takes place solely and entirely in the minds of the married couple in conjugal union with each other. Moreover, regardless of whether one views it to be moral or amoral to break up a stale marriage bond, the real issue here is whether chemical units in a marriage pair, i.e. reactants, have any real choice in their election or affinity, whenever one attached species is *forced* to embrace or attach to a new species outside of the marriage bond.

The question of whether we, or the characters in the novel, have any choice in life or not is a central point of discussion in the novella. In the story, Charlotte, the wife of Eduard, the main character, after having had the technical term 'elective affinity' explained to her, insists, very characteristically, that we cannot properly speak of choice (election) in the case of helplessly parting and combining chemical substances, and that choice, the ability to choose a better course over a worse, is what uniquely characterizes human beings.[4]

This viewpoint, to clarify, characterizes one of the biggest misconceptions in the history of basic human knowledge. In short, all animate molecules, such as humans, revolving about a photon-releasing (heat-releasing) star, such as the sun, are *forced* to make *perceptual* choices due to quantum electron orbital changes in valence shell electrons of their structure. Yet, many will naively believe that human molecules, in some way being unique in the universe, make their own choices. This, of course, is incorrect in logic. The resolution of this difference, which is simply a point-of-view issue, is to note that the 'stimulus', i.e. force, will always precede the 'choice'. In other words, to prove that a human molecule has a choice in its course, one needs also to prove similarly that a hydrogen ion molecule H_2^+, a structure comprised of two protons and one electron, has a choice in its course, which is an argument in absurdity.[65]

In the novella, the chemical reaction that takes place is along the lines of [10.6], between a married couple Eduard and Charlotte (*BA*), at the end of their first year of marriage, and their two good friends the Captain and Ottilie (*CD*), respectively. The first marriages, for both Eduard and Charlotte, are described as having been marriages of financial convenience (basically arranged marriages). Specifically, when they were younger, Eduard was married off to a rich older women through the workings and insatiable greed of his father; Charlotte, likewise, when her prospects were none the best, was compelled or obliged to marry a wealthy man, who she did not love.

Moreover, both Eduard and Charlotte had previously stated intense desires for each other when they were younger, but their passions for each other in the present were oddly out of sync. In the novella, this precarious lack of passion is explained via age differences. Charlotte tells Eduard that in their early years 'you were eager for a closer union, I did not consent at once: our ages being roughly the same, I, as a woman, had doubtless grown older than you had as a man.'

On average, couples in their first marriage tend to be closer in age, by 2-3 years, whereas those in second or third marriages tend to be separated by greater age differences, i.e. 5-30 years. These numbers, of course, vary per region and decade. In 2000, in Canada, for instance, first-time brides were 31.7 years old, while grooms proclaimed their first marriage vows at an average age of 34.3. Men in their early twenties, generally, prefer women who are two and a half years younger, men in their thirties prefer women who are five years younger, and men in their fifties prefer women ten to twenty years younger.[66] In United States, for example, couples in first marriages are separated in age by three years, couples in their second marriage by five years, and those in their third marriage by eight or more years.[67] In Sweden during the 1800s church documents reveal that men who remarried following a divorce selected new brides 10.6 years younger on average.[68] In polygynous cultures, such as the Tiwi of Northern Australia, differences are even greater: high-status men often have wives who are two to three decades younger than they are.[69]

These increasing age separations can be explained by dissimilarities in fertility curves. In transitional societies, such as Senagal, for example, male fertility peaks at age 38, but men can remain potentially fertile into their early 70s. Female fertility, however, peaks early at age 27, but women can remain potentially fertile into their early 50s.[70] Hence, optimal physical bonding, in relation to fertility curve potentials, competes with the desire to have an optimal mental bonding to someone, i.e. a desire or tendency to neurologically or psychologically attach with age-similar people near in experience, activity level, personality, outlook, fitness, and predisposition, etc., which together yield characteristic overall bonding trends per decade, approximately.

Hence, in the novella, when Eduard and Charlotte were young their personalities and age differences were similar and thus more optimized for each other and there was great passion. Now, however, having been 'set free' from their first marriages

owing to happenstance, they are trying to rekindle their past passions, but their similar ages are out of since with nature. In other words, they are too close in age for their second marriage to have optimized passion, compared to other potentials.

Another fascinating detail, which is one of Goethe's hidden gems, in the novella is that each of the four main characters has a similar name: both Eduard and the Captain, it is told, had the nickname of OTTO in childhood, and the two women, CharlOTTe and OTTilie, have related names. It is likely that Goethe situated this curious puzzle piece to signify the reality that each character in the novella or each human in the world, underneath, is simply a different chemical species, each with varying amounts of affinity for one another.

In this manner, where each character is viewed as a chemical species, although Goethe destroyed all of his notes and early manuscripts prior to the final version, it is extremely likely, based on the scientific complexity, depth, and thoroughness of each chapter, that Goethe would have draw out a human affinity table, similar to the one below:

Goethe's 1809 Human Affinity Table

Edu	Cha	Ott	Cap	Luc	Mit	Cou	Bar	Nan	Ass	Arc
Ott	Edu	Edu	Edu		Edu	Bar	Cou	Ott	Ott	Ott
Cap	Cap	Cha	Cha		Cha	Edu	Edu			
Cha	Ott				Cap	Cha	Cha			
Bar	Oto	Oto			Ott					
Cou		Ass								
Mit		Arc								
Oto	Bar	Cap								
Luc	Cou	Gar								
Eld					Bar					
Hom		Luc		Ott	Cou					

This 'rough' human affinity table, partially filled out, is based on the descriptions of the affinity tendencies and reactions that occur in the novella. Spaces are left in this table to indicate relative amounts of mutual repulsion, e.g. supposing that there were more potential species to be filled in. In the novella, for example, when the young and charming Ottilie *Ott* arrives at the estate, she displaces Eduard *Edu* in his bonded activity associations to the Captain *Cap*, to form the Eduard-Ottilie companionship, i.e. the attached relationship *Edu-Ott*. Likewise, each dominant reactive species, in the table, and his or her description is detailed below:

Main Characters (central reactants)

- [Edu] **Eduard** (B) – wealthy baron in the best years of his life; he follows his instincts.
- [Cha] **Charlotte** (A) – Eduard's wife who is renowned for her aplomb in difficult social situations; she diffuses conflict, smooths over unpleasantness. She, like Mittler, is a great fixer and tries to fix Ottilie for marriage with Eduard, the Captain, and the Assistant.
- [Cap] **Captain** (C) – a man of knowledge, talents, and ability, but presently unemployed, through no fault of his own; becomes a major after the war.
- [Ott] **Ottilie** (D) – Charlotte's niece sent to boarding school, so that she and Eduard could be alone and happy. Not developing well in school or showing accomplishments.
- [Luc] **Luciane** – Charlotte's vain and obnoxious daughter, who is sent to boarding school so that Charlotte and Eduard can be alone and happy; excels very well at school in all areas. She displaces a vitality which is merely social.
- [Mit] **Mittler** – the 'mediator', a previous cleric that is good at resolving disputes who had won a considerable amount of money in a lottery and bought a modest estate. He seems to reek nothing but havoc when he intervenes. He is the spokesperson for the sanctity of the marriage bond.
- [Cou] **Count** – he wishes to marry the Baroness, but his hindered from doing so because of his unwanted marriage contract to his arranged wife. He is the spokesperson for the dissolution of the marriage bond arguing that marriages should be done by contract for a set number of years.
- [Bar] **Baroness** – she wishes to marry the Count, but is hindered from doing so.
- [Oto] **Otto** – the misfortunate child born out of the 'double adultery'.

Support Characters (side reactants)

- [Pri] **Principle** – principle or head supervisor at Ottilie and Luciane's school.
- [Ass] **Assistant** – the assistant to the Principle of Ottilie's school; prophecies that Ottilie will be a source of happiness to herself and to others.
- [Arc] **Architect** – falls in love with Ottilie while renovating the chapel on the estate.
- [Nan] **Nanni** – a poor servant girl to whom Ottilie gives her food to.
- [Gre] **Great Aunt** – the person with whom Luciane lives with after graduation.
- [Law] **Lawyer** – comes to the estate to collect money owed on matters concerning cemetery reconstruction burial rite tensions.
- [Par] **Parson** – aged pastor who is given a *coup de grace* by Mittler.
- [Sur] **Surgeon** – appointed by the Captain to administer aid to those in need.
- [Gar] **Gardener** – says it's a pleasure to work for her Ladyship; enjoys discussing planting arrangements with Ottilie.
- [Eld] **Elderly clerk** – a man with who Eduard had been dissatisfied with in the past.
- [Hom] **Homeless people** – Eduard despises them and restricts and regulates their efforts while he is married to Charlotte, but then feels compassion for them when in a state of love with Ottilie.
- [Eng] **Englishman** – acquaintance of both Eduard and the Count.
- [Tra] **Traveling companion** – friend of the Englishman.

Backdrop Characters (structure reactants)

[Loc] **Local boys** – keeps the gardens tidy. [Vig] **Village girls** – sewing, knitting, and spinning. [Vil] **Villagers** – church, people working (out of site); the people are kept at a distance, neither Eduard nor the Captain, the upper social class, want any relationship with them other than command. [Ser] **Servants**, [Gam] **Gamekeepers**, [Gst] **Garden staff**, [Val] **Valet**, [Joi] **Joiner**, [Uph] **Upholsterer**, [Pai] **Painter**, and others.

In the novella, each of these characters (reactants), through story-line, form, make, or cultivate and or break various working (functional) and non-working (dysfunctional) human chemical bonds as each chapter progresses. Moreover, as mentioned, certain characters have affinities or repulsions to certain focal points of land on the estate. Charlotte and Ottilie, for instance, are both strongly attracted to the church with its adjoining cemetery, while Eduard dislikes crossing it, and Mittler categorically refuses to enter it. Similarly, Ottilie likes taking walks by the lake to baby-sit, while Charlotte has her premonitions.

The moral teaching exemplified by each human affinity relationship or reaction, according to Goethe, is to highlight or exemplify the invariable reality that, in nature, the indictment of wrong living is merciless. The novel confronts its characters with the monstrous consequences of repressing what little 'real life' they have in themselves, a life so far removed from their *natural states* that it appears to them as something terrible and destructive. The novella positions the view that straining to remain bonded to someone in a subpar or faltering affinity relationship, for the sake of either legal, social, or perceived moral correctness is not the healthiest way to live; and what is unhealthy, generally, is also immoral. What exactly constitutes wrong living, however, is a matter of decisive interpretation.

In any event, by directly confronting chemistry with life, Goethe meant to inquire whether human life is governed by chemical laws.[12] German historian Jeremy Adler, with his 1987 book *Goethe's Elective Affinity and the Chemistry of its Time*, thoroughly studied Goethe's use of chemical theory in *Elective Affinities*. By extending the reference of an established chemical theory to encompass social interactions, according to Adler, the novel provides the basis for a universal theory of affinity. No other novel of world literature makes such a detailed and extensive use of scientific doctrine.[12]

Immediately upon publication, Goethe's novella was universally viewed as a scientific treatise on the chemical origin of love.[1] This point was agreed upon; yet in reference to how it applied to the life-long sanctity of sacred marriage, there was no agreement. When *Elective Affinities* appeared it was felt by some to be very immoral and by others to be a very moral book. The division was according to whether readers thought Goethe upheld the institution of marriage or undermined it.[4] This conflict, which exists in the present, essentially, is the difference between the imperfect legalities of governmental laws, social ideals, or scared scriptures, which

invariably declare that man and woman must bond in matrimony for eternity, and the science of chemistry, which explains that each chemical bond has a distinct half-life that varies per molecular structure or chemical species. In other words, the conception of an eternal bond is not found in chemistry.

Goethe, in short, conducts an external observer experiment with the lives of people who are living badly. Charlotte and Eduard, according a book review by *Oxford University Press*, are aristocrats with little to occupy them, who invite Ottilie and the Captain into their lives and against morality, good sense, and conscious volition are all four drawn into relationships as inexorably as if they were substances in a chemical equation.[71] Similarly, according to book reviewer Guillermo Maynez, Goethe demonstrates that 'love is not a matter of conscious decision-making; that we cannot control at all who we fall in love with, and that it is absurd to try to fight against it.' Moreover, from Maynez's view, *Elective Affinities* it is not a defense of promiscuity, as some have stated, but an argumentation about an undeniable truth.[72]

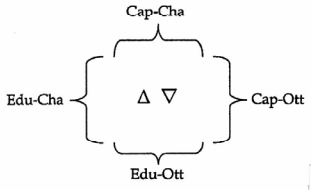
Elective Affinities, the book itself, is about 240-300 pages in length, depending on publisher, and is divided into two parts, separating respectively the good times and the bad times, each containing eighteen short chapters. Moreover, within each fascinating chapter, there is a depiction of some curious variation of an affinity reaction between the numerous characters in the story. Here, owing to page constraints, we will not be able to dissect each reaction in the novella; the reader, however, is strongly encouraged to read Goethe's *Elective Affinities*, several times.

The first chapter opens in a gardening scene. Eduard, a rich baron, is engaged in grafting newly cut scions onto young rootstocks, while his wife Charlotte is arranges the estate's new gardens and has just finished building a moss hut. They plan to manage the estate themselves and to build a summerhouse as a focal point of the newly designed landscape. Eduard takes the opportunity to propose that they enlist his life-long friend, the Captain, to help with the project. Temporarily in need of living an active, more productive life, the Captain is now unemployed, through no choice of his own, and has skills that will be advantageous to their plans. Charlotte, however, has misgivings and reminds Eduard of their decision to resist intrusions on an intimacy that is the more precious because they were delayed in their union to each other by their first marriages of convenience. They are now at the end of the first year of the union they had both desired since their youth.[7]

Distressed by letters that Ottilie, the daughter of Charlotte's deceased bosom friend and now her protégée, is not flourishing at the boarding school she attends with Charlotte's own daughter, Luciane, Charlotte acquiesces in the headstrong Eduard's wish to take his friend the Captain, in hopes that Ottilie may be allowed to join them as well. Charlotte had once, when she was younger and not in love with Eduard, intended Ottilie as a new life's partner for him, but he had, however, only eyes for her. Although she secretly fears that Ottilie might now attract his attention

after all, thus possibly undermining their marriage, she is willing to take the risk so to see what results.[7]

Through this terse introduction, Goethe is attempting to elaborate on the premise of the story, i.e. a human double displacement reaction, so to thus prepare the reader for his human reaction plans, a scheme which is outlined below in the form of a Bergman-style double affinity reaction schematic, an affinity schematic that Goethe would have likely made:



Reactants

Edu-Cha = Eduard and Charlotte (in a tepid marriage)
Cap-Ott = Captain and Ottilie (two good friends)

Products

Edu-Ott = Eduard and Ottilie (in a passionate relationship)
Cap-Cha = Captain and Charlotte (in a zestful union)

Notes

Δ = heated reaction (occurs mostly by day in the summer)
∇ = aqueous (H_2O) reaction (occurs near to rivers and ponds)

The schematic shows a human chemical reaction in which species *Eduard-Charlotte* (Edu-Cha) and species *Captain-Ottilie* (Cap-Ott) chemically decompose each other in a modified reacting system, in which water ∇ abounds, in the form of rivers and lakes on the estate, and in which daily radiant heat energy Δ, in the form of photons from the sun, drive the reaction, such to produce species *Captain-Charlotte* (Cap-Cha) that remain in the system (upward bracket), i.e. they intend to live on the estate, and species *Eduard-Ottilie* (Edu-Ott) that precipitates out of the system (downward bracket), i.e. they intend to move off of the estate and to live in house in a remote town.

The book as a whole follows, essentially, the above reaction scheme. If we step through the story chapter-by-chapter, however, a different picture emerges along the way. The opening chapter obviously is a synopsis of Goethe's central message. References to the life-defining yet elusive word 'work' are made seven times in the first three pages alone. Eduard, trying to pass the time by grafting young trees with shoots, avoids looking over the steeple of the church, from his comfortable hill-top estate, because, as he says, he might actually 'see people working.' The gardener, in contrast to Eduard, says 'it's a pleasure to work for her Ladyship' (Charlotte). The Captain, in his present state of unhappiness, as Eduard explains, is in desire of proper employment, though trough no fault of his own. Moreover, according to Eduard 'his real misery is that he has no employment. It was always his pleasure, indeed his passion in life, to use the many different talents he has developed in himself daily and hourly for the benefit of others.' In addition, 'and now to be idle, being unable to use what he possesses in such abundance' is an unhappy situation.

Here, we see Goethe digging into the idiom that a life not well-lived or worked well is a life not worth living or, in a chemical sense, a life not well-reacted is a life not having lived up to its full chemical potential. In other words, a good hard functionable life's work output is a necessary by-product of a good human reaction. Throughout the novella, for example, references are made to the effect that when a person is reacting well, their 'natural energy' and helpfulness is put to more frequent and effective use. The scientific basis behind this logic derives, essentially, from the necessary and inevitable tendencies of chemical potentials μ associated with each molecular species in evolving systems. The rule, as discussed, is that chemical species tend to diffuse from regions of high chemical potential to those of low chemical potential.[73] In human reaction terms, as a each substrate-attached human molecule diffuses along these basic potential gradients, work output will be a product; this will have the effect of decreasing the chemical potential along the way. In short, at the end of a good, well-lived life, a person will be spent in potential. In psychological terms, a reactive person in a region of optimal diffusion, i.e. one in which he or she is expending their inherent chemical potentials at an optimal rate, will correlate with the psychological concept of 'flow' or optimal experience.[74]

In the close of the first chapter, Eduard says, essentially, that they are going to write to the Captain so to invite him to come to the estate. Moreover, using chemical metaphors, he says, they shall see what 'precipitates' out of the situation. Goethe, no doubt, was modeling this reaction along the lines of something akin to Bergman's single elective affinity reaction [10.4]. In other words, species *Edu-Cha*, in the fluid system of the estate, are going to invite species *Cap* into their reaction system, whereby they will see what entity precipitates out of the solution. When mixed, it follows that a newly bonded species *Edu-Cap* form as a unit, i.e. become inseparable as friends, remaining fluid in the estate (upward full-bracket), whereas species *Cha* is displaced or precipitates out of the solution (downward half-bracket), to an extent.

In the groundbreaking fourth chapter, the characters detail the world's first ever verbally-depicted human *double displacement* chemical reaction [10.6]. The chapter begins with description of the affinity map (reaction map) or 'topographical chart' as Goethe calls it. On this reaction map, we are told that on it 'the features of the estate and its surroundings were clearly depicted, on quite a large scale, in pen and in different colors, to which the Captain had give a firm basis by taking trigonometrical measurements'. This is equivalent, in modern times, to the use of trigonometric measurements of approach angles and topologies on free energy maps when modeling the encounter complex between two or more molecules on a receptor surface grid.[75]

Next, to explain the reaction, we are told 'provided it does not seem pedantic,' the Captain said, 'I think I can briefly sum up in the language of signs. Imagine an *A* intimately united with a *B*, so that no force is able to sunder them; imagine a *C* likewise related to a *D*; now bring the two couples into contact: *A* will throw itself at

D, *C* at *B*, without our being able to say which first deserted its partner, which first embraced the other's partner.' This is shown below:

$$AB + CD \rightarrow AC + BD \qquad [10.6]$$

'Now then!' Eduard interposed: 'until we see all this with our own eyes, let us look on this formula as a metaphor from which we may extract a lesson we can apply immediately to ourselves. You, Charlotte, represent the *A*, and I represent your *B*; for in fact I do depend altogether on you and follow you as *A* follows *B*. The *C* is quite obviously the Captain, who for the moment is to some extent drawing me away from you. Now it is only fair that, if you are not to vanish into the limitless air, you must be provided with a *D*, and this *D* is unquestionably the charming little lady Ottilie, whose approaching presence you may no longer resist.'

Beyond all comparison, this is indeed a revolutionary paragraph! To present the process of human life in so simply yet elegant of a formulaic manner, for this period in history, is a watershed moment. Beyond this, Goethe explores the nature of love and questions whether we have any choice over who we love or over anything at all.

Technically, the human chemical reaction [10.6] depicted above, between the four main characters, follows a specific number of intermediate steps, as each human chemical species (character) is introduced into the story (reactor vessel), chapter by chapter. In short, the chapters do not follow, word-for-word, that of [10.6] to the detail. For one, the Captain *C* and Ottilie *D* are not dropped into the reaction as a bonded pair *CD*, as would be the case in a true double displacement reaction. Other characters, however, such as the count and baroness, are dropped into the reaction vessel as paired species. The central reaction [10.6] is in fact *multivalent*, meaning that each species has multiple simultaneous bonding tendencies, which invites other possible interpretations. This has resulted in a number of published discussions on the matter.[76]

In mechanistic terms, in the beginning of the novella, Edward *B* and Charlotte *A* invite the Captain *C* to stay with them (step one) as shown below:

$$AB + C \rightarrow A\text{-}B \text{ - - - } C \qquad [10.7]$$

Here we use dash spacing to indicate the closeness of the bond. Next, the captain begins to reform his old bonds with his long-time friend Edward, thus pulling him away from Charlotte (step two) to a certain extent, as they begin to socialize with each other more and more:

$$A\text{-}B \text{ - - - } C \rightarrow A \text{ - - - } B - C \qquad [10.8]$$

Then, to appease Charlotte's wishes, Edward and Charlotte agree to invite Ottilie *D*, charlotte's adopted niece, to stay with them for some time. Upon her arrival, they all get acquainted, frequently meeting up for lengthy dinners, teas, and walks. For this group get-together reaction, Goethean historian Jeremy Adler postulates that Goethe may have had the following chemical reaction in mind (step three):

$$AB + CD \rightarrow ABCD \qquad [10.9]$$

This reaction coincides with a formula that Goethe would have known from German chemist J. B. Trommsdorff's noted 1805 *Systematisches Handbuch dre gesammeten Chemie*. In 1795, for example, Trommsdorff had founded Germany's first chemical and pharmaceutical institute in Erfurt, hence Goethe would have likely been familiar with his work.[77] This reaction may also express a similar double affinity theory that was presented by French chemist Claude Berthollet in 1803. According to [10.9], one could also imply that, to a certain extent, the characters remain friends and that old relationships continue till the end of the novella, as this reaction suggests. Nevertheless, following their acquaintance period, the four friends divide, relax a bit, thus loosening up their relative bonds with each other, so to begin to possibly find their evolution place in the new system (step four):

$$ABCD \rightarrow A - - B - - C - - D \qquad [10.10]$$

Next, the Captain *C* and Charlotte *A* begin to tighten their mutual bond as they work on various town projects and activities together (step five):

$$A - - B - - C - - D \rightarrow A\text{-}C - - B - - D \qquad [10.11]$$

By way of this reaction dynamic, Edward *B*, as Goethe states, is 'thrown into' the charming company of Ottilie *D* (step six):

$$A\text{-}C - - B - - D \rightarrow A\text{-}C - - - - B\text{-}D \qquad [10.12]$$

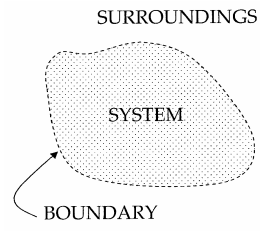
From here, the precarious reaction teeters on the brink of separation and complete transformation, and it is here that we see the reality and true power behind relentless nature of the chemical world. To summarize, according to book-reviewer Melvin Pena, 'when the passionate Eduard meets the youthful energetic Ottilie and the stoical Charlotte meets the likewise prudent Captain, the scientific principle of *elective affinities* that gives the novel its name begin to take effect. The result of introducing two new elements into a *closed system* makes up the action of the remainder of the novel.'[78]

The term *elective affinity*, to review, an historical precursor to the modern-day term chemical affinity, refers to the tendency of an atom, molecule, or compound to combine by chemical reaction with atoms, molecules, or compounds of similar or dissimilar composition.[79] Affinity in modern terms can be defined as follows:

> **Affinity** – the force of attraction, or bond, between atoms that helps to keep them in combination in a molecule; also applied to attraction between molecules, such as those of biological significance.[80]

In early nineteenth century chemistry, the concept of elective affinities was used to describe compounds that only interacted with each other under select circumstances; Goethe used this as an organizing metaphor for marriage and the conflict between responsibility and passion. The term *closed system* refers to a bounded region of confinement in which the system does not exchange matter with its surroundings. A closed system may, however, exchange energy in the form of work or heat with the surroundings.[81]

When analyzing the thermodynamics of all human interactions, an important concept, as discussed, is that of the 'system' (working-body). A *system* is any region of the universe under study. A system is separated from the remainder of the universe by a *boundary* which may be imaginary or not, but which, by convention delimits a finite volume:



The possible exchanges of work, heat, or matter between the system and the surroundings take place across this boundary. There are four dominant classes of systems:

1. **Isolated systems** – nothing may cross the boundary.
2. **Adiabatic systems** – heat and matter may not cross the boundary.
3. **Closed systems** – matter may not cross the boundary.
4. **Open systems** – heat, work, and matter may cross the boundary.

In short, the 'boundary' is simply an imaginary dotted line drawn around the volume of a region reactive matter under study in which there is going to be a change in the internal energy of that region. Anything that passes across the boundary that effects a change in the internal energy of that volumetric region needs to be accounted for in the energy balance equation, as is quantified by the first law of thermodynamics.

The first law of thermodynamics for open systems, for example, states that 'the increase in the internal energy of a system is equal to the amount of energy added to the system by matter flowing in and by heating, minus the amount lost by matter flowing out and in the form of work done by the system.' The first law for open systems is given by:

$$dU = dU_{in} + \delta Q - dU_{out} - \delta W \qquad [10.13]$$

where U_{in} is the average internal energy entering the system and U_{out} is the average internal energy leaving the system. Through derivation, expression [10.13] can be written in terms of differential changes in the Gibbs free energy dG in the system, such as in [9.4]. Human systems can be modeled as open, closed, or quasi-closed, depending on the discussion and the time frame of the reaction process.

A system, subsequently, can be the volumetric region surrounding a single atom resonating energy, such as Max Planck defined in 1900, it can be a body of steam or air in a steam engine, such as Sadi Carnot defined in 1824, it can be an evolving society of human beings, such as Georgi Gladyshev outlined in 1977, it can be the body of a tropical cyclone, such as meteorologist Kerry Emanuel theorized in 1986, or it can a single nuclide, i.e. a system of three quarks bound by gluons, as some are theorizing presently in quantum thermodynamics.

The earth-system, as mentioned, is gravitationally closed at a boundary called the *Karman line*, the earth-space delineation sixty-two miles above the earth's surface where weightlessness begins. Here, heat or solar energy fluxes across this boundary at a rate of 1370 W/m^2; whereas matter, within the temporal confines of daily human evolution, is relatively confined to the system.[82] For subsystems, e.g. human reacting systems, within Karman-line-system, one needs to define both the system, the boundary, and the time delineation for the reactionary process under study. Within specific windows of view, or characteristic stages of life, human reacting systems are facilitatively modeled as closed systems. In other words, people do not change their addresses on a daily basis, but rather they stay and react in certain confined regions for extended periods or evolutions of time. Over the course of many years, however, human systems can evolve considerable and be considered as open reactive systems, in which new reactive humans enter or leave. Each particular system, of course, requires finite and detailed analysis. Over extended periods, on average, human systems and boundaries will change continuously.

To illustrate the basic difference between an 'open' and 'closed' human system, a good example is a school-system. Over a continuum of decades, a continuous flow of students, i.e. reacting human-molecules, will pass through any typical high school system; in this manner we have an 'open' system. Yet, within the delineation of one school year, the flow of students across the boundary stops. Students will, of course, go home at night and to other places and react in various extracurricular orbitals, but

with reference to the internal energy of the school system, specific system-defined reactions will occur between the students and the teachers. Within this timeframe and from this orbital-selective point of view, the student body will remain constant, the educational staff remains constant, and nutritional sustenance, defined here as substrate interaction, is constant. In addition, over the course of the school year, parents, faculty, and the community, will input a measurable amount of work and energy into raising and educating the students. These significant energy inputs can be quantified as work done on the system. It this manner, human systems can be modeled as either open or closed system, depending on boundary conditions.

The *closed system* we meet in the Goethe's novel is a small, relatively isolated, town called Weimer in Germany.[83] Weimer is the depiction of a society along a region of countryside at the beginning of the nineteenth century. In this period, three-quarters of all Germans lived on and by the land, and towns were still small and far apart. In this milieu there were three social classes: the *nobility*, who owned the land and occupied leading positions in the army and the civil service; the *middle class*, those who occupied the professions; and the *people*, who were for the most part peasants.

Social hierarchies generally are a result of structural stability tendencies. For human reactive systems smaller than the *Dunbar number* 150, a term proposed in 1992 by British anthropologist Robin Dunbar, which measures the 'cognitive limit to the number of individuals with whom any one person can maintain stable relationships', it is found that no sort of tiered social hierarch is needed to maintain structure; each person is on a relatively equal rank.[84] At or below this size, orders can be implemented and unruly behavior controlled on the basis of personal loyalties and direct man-to-man contracts. With larger groups this becomes impossible.[85] This hierarchical stability tendency is a natural phenomenon.[86] The Hutterites, Amish, and Mennonites, for example, have a strict policy that every time a colony approaches 150, they split it in two and start a new one. The same pattern is found in modern companies such as Gore Associates, who make Gore-Tex fabric and Glide dental floss, as well as historically, with rural villages such as Walbiri of Australia or the Tauade of New Guinea, and in army units.[85]

In larger towns, a hierarchy of social structure, i.e. upper class, middle class, and lower class, is an inevitable consequence of basic chemical thermodynamic stability tendencies, such as described above. Goethe, himself, struggled deeply with the inherent tensions associated with dating or marrying outside of one's social class (energy hierarchy). In 1786, having served ten years as at the Court, in the Weimar society, as a practicing Lawyer, and after having been in a ten-year relationship with a rather severe married upper-class lady called Charlotte von Stein, Goethe broke away and traveled incognito throughout Rome, Naples, and Sicily for nearly two years. When he returned home, he affronted the social rule in Weimar by taking a

girl from the local artificial-flower factory, Christiane Vulpius, to live with him in his *Gartenhaus*, his house in the park, as his mistress.

In these types of precarious romantic situations, where natural passions are at odds with social predispositions, the answer as to which is the correct reaction path to follow boils down to a matter of potentials, namely whichever reaction potential works the best, taking in all considerations, will be optimal in that sense. The roots of the matter, however, will always be difficult to discern by one rule. That single social systems of species split, diverge, and grow apart, thus becoming socially separated and reproductively closed social collectives, separated by subtle dislikes, dissimilar characteristics, energetic boundaries, and in some cases mutual hatreds, when they grow past a certain size, density, and structural complexity, as biological evolution has clearly shown, makes for a complicated picture.[87]

Christiane, as Goethe's mistress and because of her class, was not presentable. She withdrew when guests came. But in Goethe's published correspondence with her the tone was on both sides is warmly and ordinarily human, domestic, tender, chatty, and amusing. She lived with him until her death in 1816, and bore him five children, only one of whom survived.[4] One could argue that, from a reproductive point of view, in this case, social tensions out-weighted sexual passions, although certainly other factors may have been involved.

In 1806, the fortitude of their relationship was strained, to an extent, by external forces. Earlier that year, French troops passed through Weimar after their victory at Jen and entered Goethe's household and threatened his life. Christiane behaved with great bravery and presence of mind during the situation. Owing to the uncertainty of this event and the capriciousness of life which it illuminated, Goethe, although reluctant to a certain extent, decided it would be a proper course of action to marry Christiane, so as to give her more of a lasting and legal protection during dangerous times. They were married that October with their son August as a witness.

Goethe did not, however, consider the official sanction that important to the real or natural constitution of their relationship, for as he said 'she always was my wife', but there after, the benefit was that Christiane had the legal favoritisms that go with marriage and that she could at least be taken out and introduced properly in social settings. Although Goethe, between 1788 and 1816, was in love elsewhere, more or less passionately, more or less intimately, half-a-dozen times at least, he considers his relationship to Christiane to be the 'fullest of his life'. Interestingly, similar to the destruction of notes and manuscripts of *Elective Affinities*, none of the letters written by Christiane in the tensioned years of 1804-09 survived.[4]

As such, the issue of social standing and its effects on human relationships was a dominant factor in the structure of *Elective Affinities*. In human chemical terms, the depiction of the estate and surrounding town in the novella is that of an energetically defined, hierarchical-structured *dynamical system* with three varieties of chemical species. The basic energy quantifier used in the novella is the working aspects of

each reaction. All societies have this general structure. People, on average tend to associate or react within their own social level. Transients of vertical mobility do exist, however, in which statistically women with physical appeal tend to marry up and men with financial appeal tend to marry down in a predominant manner.[88] Generally though, people have the inherent tendency to react with those from within their own energy level. Relationship researchers define this as the *equity principle*; i.e. when lovers go husband or wife shopping on the open market, predominately, the happiest couples are more or less equal in those as social status, prestige, wealth, education, etc.[89] Typically, each class is separated via huge energetic social barriers, enforced by such acidic social tools as gossip, rumors, expulsion, and hatred.

From a mathematical point of view, dynamical systems, such as atom or molecular gas phase systems are often described in terms of differential equations. These equations describe the behavior of the system for a short period of time. To determine the behavior for longer periods it is necessary to integrate the equations, either through analytical means or through iteration, often with the aid of computers. Differential equations for dynamical human reacting systems are determined via a thermodynamics mass-energy balance on each respective reactive system.[90] In constant temperature, constant pressure systems, those which characterize the biosphere, the Gibbs free energy equation results, otherwise known as the combined law of thermodynamics, such as shown below for evolution window systems:[91]

$$\Delta G = \Delta H - T\Delta S \qquad [4.11]$$

This fundamental equation, as discussed, energetically characterizes quantifiable windows of punctuated evolution equilibrium, i.e. it balances the nature of two entities: the *heat energy* supplied to and the *work energy* performed by reactant species, bonded into chemically-reactive relationships, in each reactive system.[92] In addition, to properly quantify the energy utilization of each species (character) in the system, such as those in Goethe's estate, whether bonded or single, the enthalpy and entropy measures at the before and after stages of each reaction must be measured:

$$\Delta G = H_f - H_i - T(S_f - S_i) \qquad [4.26]$$

Essentially, ΔG measures the work output of reacting systems, and is the resultant governing equation arrived upon after energy-mass balance integration.[77] Here ΔH is the total energy change of the system, including that having to do with system-boundary pressure-volume changes, $T\Delta S$ is the portion of the total system energy change which is unusable for the purposes of external work or that, according to Maxwell, which 'cannot be directed at pleasure', and ΔG is the portion of the total system energy change which is utilized in the form of work. Similarly, in biological terms, Gladyshev defines ΔG as 'the work of evolution', meaning that it is the

measure of the work used or required to build the structure of some evolving system, e.g. one society, being connected to the energy of work a molecule or person puts into the efforts related to evolution of such a system.

Dynamical systems in nature tend to be dissipative, a consequence of the second law of thermodynamics; where if there were not some driving force the motion would cease. Here the driving force, in precursory form, is the flux of solar electromagnetic energy, embodied as quantums of photons, traversing from the sun through the earth-system. The evolutionary push of this energy flux, in quantum steps, through numerous adjoined dynamical systems, as the magnetosphere, thermosphere, mesosphere, stratosphere, troposphere, tropical cell, temperate cell, polar cell, biosphere, ecosphere, social-sphere, communities, niches, networks, families, relationship-pairs, organisms, organs, cells, organelles, molecules, down to the atomic orbital level, functions or actuates as the principle driving force of life.

The dissipation, within each system, where functionable work energy is lost in the form of non-reversible types of kinetic energies or frictional energies, may come from interpersonal frictions, economic strife, collisions, thermodynamic losses, non-flow states, or material waste, among many other causes. The dissipation and the driving force tend to combine to level out initial transients over time and settle the system into its typical behavior. This typical behavior is a characteristic of all physical systems, i.e. physical systems will always stabilize into the configuration with the lowest energy level; a configuration also known as an *energy well*.[93] In mathematics, the part of the *phase space* of the dynamical system corresponding to the typical behavior is the called the attracting set or attractor.[94]

> **Point attractor** – whatever a system's initial conditions, it will be attracted toward a stationary state of minimum entropy, as close to equilibrium as possible, and its behavior will be completely predictable.[95]

An *attractor* is a set or configuration to which a system evolves after a long enough time. In mathematics and physics, phase space is the space in which all possible states or arrangements of a system are represented, with each possible state of the system corresponding to one unique point in the phase space. For mechanical systems, the phase space usually consists of all possible values of position and momentum variables. A plot of the position and momentum of each point particle or variables as a function of time is sometimes called a *phase diagram*. In the novella, a plot of the position and momentum of each human particle in the town and on the estate would make a phase diagram. The human characters, from this point of view, can be said to evolve into stable energy wells and in doing so thus arrange their lives socially, politically, and personally, according to these dynamic tendencies.

In addition, within all human reacting systems, attractors are periodic. Owing to the diurnal force or flux of solar energy in the form of gamma-ray photons, fluxed on

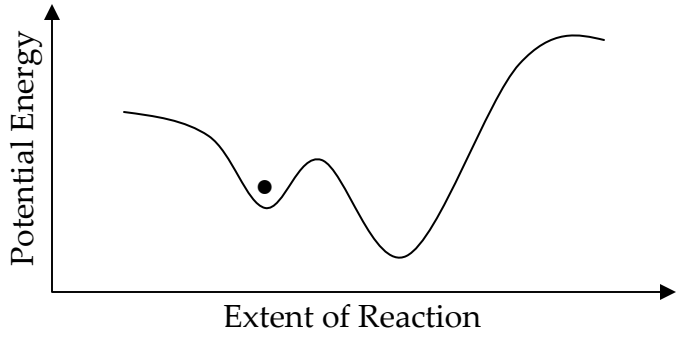
essentially a twelve-hour per day basis, attractor sets are always transient, i.e. change is inevitable. Yet, due to the quantum nature of the photon, i.e. that electrons will only change energy levels at certain fixed 'quantums' of energy input or energy release, earth-bound dynamical systems are situated within certain quantum windows of focal stability, in which they evolve.

In the novella, the closed system referred to is a spacious estate situated near to a quaint village many miles from the nearest city. Predominately, this estate-village system functions in an autonomous manner. When the upper class, in their affluent yet mundane social spheres, according to Goethe, are not engaged in military or governmental activities they are *idle*, i.e. lacking worth or basis, and it is in this idle state, or phase-space of focal stability, that the aristocrats of *Elective Affinities* are found. How they fill up their time, in their estates, is a subject of much of the narrative. Their activities vary widely, but they are all characterized by the expenditure of a large amount of energy for what are at best inadequate results.[96]

When discussing the ramifications associated with bringing the Captain to their home, i.e. the introduction of a third reactive component into a closed system, for example, Eduard states 'the Captain's presence will disturb nothing, but rather expedite and enliven everything.' Here again is the debate on the issue of whether or not life should be lived. Yet, Charlotte replies 'I have a premonition that no good will come of it. There is nothing of more significance in any situation than the intervention of a third party. I have known friends, brothers and sisters, lover, married couples, whose relationship has been altogether changed, whose life has been turned upside down, by the chance or intended arrival of another person.'

Reflecting to himself, the next day, Eduard reasons that up to that moment he had everything he had ever wanted. He had even got Charlotte; he had at long last won her through an obstinate constancy which bordered on the fabulous. But now, just as he was also going to get the friend of his youth and thus so to speak round off his whole existence, he felt for the first time contradicted and crossed. These conflicts and energetic tensions are accounted for via entropy ΔS term, which, from one perspective, can be thought of as a measure of internal work tensions.

Here, in human thermodynamic terms, we are referring to what is called an *ambivalent state*, one that is semi-stable (metastable), in a transitory energy-well. In other words, the reaction could go either way, meaning that each outcome seemingly is equally probable or in some way energetically equivalent. The energetic state of this ambivalent situation is depicted in the following diagram:

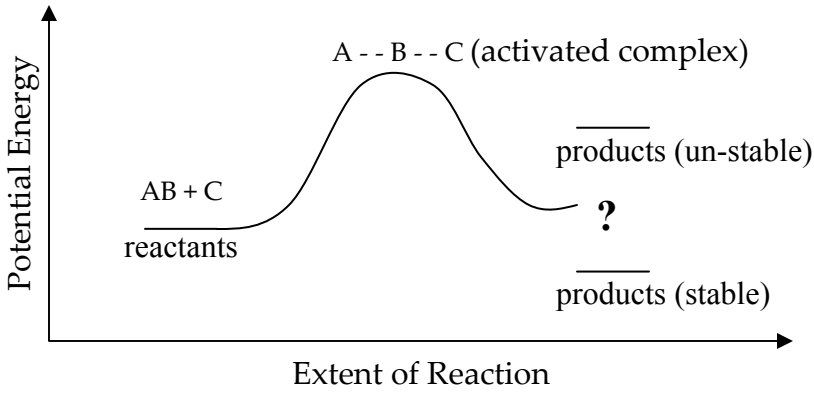


Here, the human particle ● is stuck in a semi-stable energy well, where from within which it is difficult to tell which path is the more stable one to follow, being that both the forward and reverse paths seem equally favorable, from a system-internal perspective. The mechanical analogy for a chemical system is a ball on a slope. Mechanical systems have a tendency to change so as to reduce their *potential energy* to a minimum.[97] A ball at the apex of a hill, for example, will tend to spontaneously roll down into the valley, losing potential energy as it goes, seeking the lowest point it can reach. Upon reaching this point, it will come to rest (equilibrium) at the bottom of a valley.

A person in an unstable energy well, in an analogous manner, is a very precarious situation. Any small perturbation can dislodge the person or particle and, as such, send it in a possibly fortunate (more-stable) or unfortunate (less-stable) direction. A person in this type of situation is pulled in both directions and confusion abounds. Ultimately, Eduard *B* invites the Captain *C* whereby upon arrival, their rekindled friendship begins to pull Eduard away from his dear Charlotte *A* into a high energy *transition state* complex, A --- B --- C. In this situation, bonds are stretched to their maximum. This reaction intermediate is depicted below, being the first step in Goethe's human chemical reaction storyline:

$$AB + C \rightarrow A - - - B - - - C \qquad [10.14]$$

A *transition state* is the highest point on the *reaction coordinate* corresponding to the time period in which the *activated complex* forms, whereby dynamic molecular reconfigurations proceed. If the activated complex proceeds to a point higher on potential energy reaction schematic, than as compared to its initial position, the products will be less stable. If the activated complex proceeds to a lower potential energy well, the products will be more stable. This difference is depicted below:



In this reaction diagram, the question mark is used to indicate the basic reality, that from the vantage point of the reactants, it is difficult do discern whether or not the outcome, i.e. products, will be a stable or favorable situation. Different people will use different decision mechanisms to gauge these types of potential barriers. Some follow their heart, some go with their instinct, some think rationally about their predicament, some use intellect, some go with their gut, some ask for advice, and others use combinations of these discernment mechanisms. Physically, however, only before and after energetic stability considerations will determine feasibility.

In any event, through the start-to-finish process of any chemical reaction, human or otherwise, the transition state corresponds to the intermediate stage of the reaction in which reactants proceed through a continuous change in their relative positions, bondings, configurations, and potential energies to be then transformed into products. The transition state may be thought of as the intermediate configuration, or 'activated complex', between the initial and final bonding arrangements of the atoms, molecules, or species involved, in which the energy arising from interatomic and intermolecular forces (potential energy) reaches a maximum. This *transition state theory* as described here, however, was not articulated fully until about 1931 when Mexican-American theoretical chemist Henry Eyring and Hungarian–British physical chemist and polymath Michael Polanyi began constructing a potential energy surfaces for chemical reactions.[98]

Building on this, in the story the term 'affinities' is introduced by Eduard when Charlotte asked him to educate her on how to remove the *verdigris*, $Cu(C_2H_3O_2)_2 * H_2O$, a greenish blue poisonous pigment that tends to form on copper due to action of acetic acid CH_3COOH from the pots; this leads naturally enough to an exposition on 'the fundamental principles of physics and chemistry', as Edward states. We are told, by Eduard, that in all the phenomena of nature of which we are aware, the first thing we observe is that certain entities have the tendency to adhere. He gives the example of water, oil, and quicksilver, and states: 'these have a unity and coherence of their parts; they will not relinquish this unified state except through the action or

force of some other agent. If this is removed, they immediately come together again.'

We are told of how raindrops like to join together in to streams and how when playing with quicksilver we can easily separate it into little balls and let it run together again. Whereby, just as each thing has adherence to itself, so it must also have a relationship to other things. As such, according to Eduard 'each relationship will differ according to the differences between them, sometimes they will meet as friends and old acquaintances who hasten together and unite without changing one another in any way, as wine mixes with water. On the other hand, there are others who will remain obdurate strangers to one another and refuse to unite in any way even through mechanical mixing and grinding, as oil and water shaken will a moment later separate again.' Moreover, we are told how these principles stand out most predominately in the form of social circles, the classes, the professions, the nobility, the soldier, and the civilian. In the novella, we find '…just as these can be unified through laws and customs, so in our chemical world too there exist intermediaries for combining together those things which repulse one another.'

Expounding further, the Captain defines what affinities are and what their force consists in 'those natures which, when they meet, quickly lay hold on and mutually affect on another we call *affined*. This affinity is sufficiently striking in the case of alkalis and acids which, although they are mutually antithetical, and perhaps precisely because they are so, most decidedly seek and embrace one another, modify one another, and together form a new substance. Think of lime which evidences a great inclination, a decided *desire for union* with acids of every kind.' In analysis of these proclamations Charlotte declares 'when you call all these curious entities of yours affined, they appear to me to possess not so much an affinity of blood as an affinity of mind and soul. It is in just this way that truly meaningful friendships can arise among human beings: for antithetical qualities make possible a closer and more intimate union.'

Edward goes on to state 'it is the most complicated cases that are in fact the most interesting. It is only when you consider these that you get to know the degrees of affinity, the closer and stronger, the more distant and weaker relationship; the affinities become interesting only when they bring about divorces.' This, we are told, validates the title given to chemists in these days as being artists in divorcing one thing from another; as derived from the like phraseologies *Scheidung* = divorce and *Scheidekunstler* = analytical chemist.

Next, to provide a comparison reaction similar to that which is happening to Edward, Charlotte, the Captain, and Ottilie, the Captain give the common example in which limestone or calcium carbonate $CaCO_3$ reacts with sulfuric acid H_2SO_4 to form gypsum $CaSO_4*2H_2O$ with the release of carbon dioxide gas CO_2:

$$CaCO_3(s) + H_2SO_4(aq) \rightarrow CaSO_4(s)*2H_2O(l) + CO_2(g) \qquad [10.15]$$

In this reaction, according to the Captain, 'there has occurred a separation and new combination, and one then feels justified even in employing the term *elective affinity*, because it really does look as if one relationship was preferred to another and chosen instead of it.' Charlotte intervenes, reasoning 'I would never see a choice here but rather a natural necessity and indeed hardly that; for in the last resort it is perhaps only a matter of opportunity. Opportunity makes relationships just as much as it makes thieves; and where your natural substances are concerned, the choice seems to me to lie entirely in the hands of the chemist who brings these substances together … I can only feel sorry for the poor gaseous acid (CO_2), which has to go off and drift around again in the void.'

In rebuttal of this noted downside, we are told by the Captain, that all the carbon dioxide CO_2 has to do is to join up with another compatible substance as water H_2O and it will then, as a mineral spring, serve as a source of refreshment to the sick and healthy alike. This may be true, according to Charlotte, but the expelled substance, in contrast to the now finished and complete body gypsum, may go through a very hard time before it again finds refuge. Eduard interposes, 'unless I am mistaken,' said with a smile, 'your remarks carry a double meaning, I am in your eyes the lime which the Captain, as sulfuric acid, has seized on, withdrawn from your charming company, and transformed into a stubborn gypsum.'

In defense of her position, Charlotte states 'I know of all too may cases in which an intimate and apparently indissoluble union between two things has been broken up by a chance association with a third and one of the couple at first so fairly united driven out into the unknown.' Yes but Eduard replies, 'chemists are far more gallant in this manner, they introduce a fourth, so that no one shall go empty away.' This being a form of crosswise parting and uniting: where four entities, previously joined together in two parts, are brought into contact, abandon their previous union, and join together afresh.

In this manner, according to the Captain, 'this relinquishment and seizing, in this fleeing and seeking, one really can believe one is witnessing a higher determination; one credits such entities with a species of will and choice, are regards the technical term *elective affinities* as entirely justified.' In this manner, we are told by the Captain 'one will come into acceptance of these principles if we view the experiments ourselves. One has to have these entities before one's eyes, and see how, although they appear to be lifeless, they are in fact perpetually ready to spring into activity; one has to watch sympathetically how they seek one another out, attract, seize, destroy, devour, consume one another, and then emerge again from this most intimate union in renewed, novel and unexpected shape: it is only then that one credits them with an eternal life, yes, with possessing mind and reason, because our own minds seem scarcely adequate to observe them properly and our understanding scarcely sufficient to comprehend them.'

Sure enough, as the book unfolds, they send for charming little lady Ottilie, their distant adopted niece, to test these theories of affinity. Before her arrival, Edward *B* warns the Captain *C*: 'you just be careful of the *D*, my friend! What would *B* do if *C* were torn from him?' Upon the arrival of Ottilie *D*, bonds loosen up, and everyone settles in to their new arrangement:

$$A - - - B\text{-}C + D \rightarrow A - - - B - - - C - - - D \qquad [10.16]$$

But, shortly thereafter, Charlotte *A* and the Captain *C* find a common occupation in the construction and design of a new park; where as it is stated 'he too learned to know her better and they found it easy to work together and get something done'. In this manner, we see Goethe outlining the basic thermodynamic view that couples optimally paired produce the highest and most enjoyable work output.

As a result of the spontaneous pairing up of Charlotte *A* and the Captain *C*, in the form of a working relationship *AC*, Eduard *B* is resultantly 'thrown into the company of Ottilie' *D* to thus form a *BD* coupling. Subsequently, the group as a whole formed a new temporarily stable activated complex, all living under the guise of friends helping friends:

$$A - - - B - - - C - - - D \rightarrow AC - - - BD \qquad [10.17]$$

We are told, that the group functions together better in their new respective pairings; where it is stated that 'working together is like dancing together: if you keep in step you become indispensable to one another.' Work output in human relationships, as discussed, is measured by the change in Gibbs free energy ΔG per reaction.

A point to note, in this story, often misconstrued, is that Goethe is not trying to imply that all marriages should break up. The point that Goethe makes, is that some marriages break and that there is an inherent chemical reason behind such breakups. The basic difference between those pairs that continue to react and those that don't is a more advanced topic involving human chemical kinetics, human thermodynamics, and reaction rates, but which basically comes down to energy stabilizing effects.

In chapter nine, we find another fascinating human chemical reaction, namely a displacement reaction described verbally. In short, Eduard *B*, Charlotte *A*, the Captain *C*, and Ottilie *D* are entertaining Mittler *E* for the day, but when he hears that the Count *F* and the Baroness *G* are in the area he quickly gets his hat and riding-crop and leaves. He states that he is being 'driven away', for he will 'not be under the same roof with them.' This reaction is depicted below:

$$ABCD\text{-}E + FG \rightarrow ABCD\text{-}FG + E \qquad [10.18]$$

Or, using labels from our human affinity table manner:

$$ABCD\text{-}Mit + CouBar \rightarrow ABCD\text{-}CouBar + Mit \qquad [10.19]$$

The reason Mittler leaves is a result of the different or incompatible viewpoints he has with the Count and the Baroness on the topic of marriage. Marriage, according to Mittler, is the foundation of all moral order, and that 'anyone who in word and worse in deed undermines that foundation' will have him to deal with. The Count and the Baroness, conversely, are inclined towards the idea of a natural divorce, when the situation should present itself. Here we see mental entropic effects acting to determine reaction direction.

The Count and the Baroness, some time ago, were both already married, but had fallen passionately in love with each other. Both marriages were shaken, and not without scandal; there was talk of divorce. In the case of the Baroness it became possible, but not in the Count's. They were obliged to pretend to separate, but their relationship continued; and though during the winter they could not be together, they made up for it in the summer when they could travel and visit the spas.

Mittler, on the other hand, was the spokesperson for the sanctity and fortitude of the marriage bond. Marriage, according to Mittler, 'is the basis and pinnacle of culture.' It makes the uncultured gentle and in it the most cultured can best demonstrate their gentleness. It must never be dissolved, in Mittler's view, 'for it brings so much happiness that in comparison any individual unhappiness is of no significance.' He continues 'and what do people mean when they speak of unhappiness? It is impatience, which comes over them from time to time and then they are pleased to call themselves unhappy. Only let the moment pass and you will think yourselves fortunate that something which has stood so long still stands. There is never sufficient reason for separation.'

Mittler, as we see, is an idealist. In chemistry, separation is just as or, in some cases, more important as is fusion. This is where the conflict lies. Certainly, many can and do find perfect bonds, in which a pair is matched such that they continue to react well past their golden-wedding anniversary. In other words, when a paring has been optimized as compared to most other possible pairings around them, and unless each person travel around the world to interact with the few other pairings that could increase or outdo that initial pairing, in basic stabilizing effects, they will remain bonded. These 'ideal' situations, however, are not as commonplace as Mittler would like them to be.

In chapter ten, the Count *F* and the Baroness *G* arrive and the group of six mix and mingled together. It is stated that 'old memories and a present interest mixed and a rapid and lively talk drew everyone together.' But before too long, there was a 'separation', the 'women withdrew to their own wing of the house, and in exchanging confidences and at the same time began to appraise the newest fashions in morning wear, hats, and suchlike, they found plenty to amuse them, whilst the

men gave their attention to the new carriages and had horses brought out at once and began to deal and swap.' This separation reaction is depicted below:

$$ABCD\text{-}FG \rightarrow BCF + ADG \qquad [10.20]$$

Interestingly, in this depiction we see Goethe verbally referring to primary and secondary field particle exchanges as being part of the bonding process. That is, they 'exchanged confidences' and 'swapped deals', which is a rudimentary form of modern day, quantum mechanical, field particle or virtual particle exchange used in the definition of the human chemical bond.

Beyond these core examples, according to Goethean historian Jeremy Adler, a large number of the affinity examples in the novella are outlined on Macquer's seven types of affinity, a modification of his previous six types of affinity, as found in his 1766 *Dictionary of Chemistry*. These basic affinity types were used in a similar manner by Bergman in 1775; hence it is likely that Goethe used them as well for reaction models in the novella.

The first is *affinity of aggregation or cohesion*, which Bergman defines as a type of contiguous attraction in which homogeneous bodies tend to union, an increase of mass takes place, and in which the nature of the body remains the same. Macquer defines it as that which works between the 'integrant parts', i.e. parts that can be divided mechanically, of the same body to bring them together in a state of aggregation or homogeneous mass.[99] The Captain explains it in abstract terms as a thing's 'relation to itself'. Eduard gives an example: 'just imagine water, oil or quicksilver: you will find that they display a unity, a cohesion of parts. Similarly, Macquer writes of the 'tendency to combine which two drops of water, or oil, or quicksilver … display towards one another.'[100]

The second type is *affinity of composition*, which Bergman defines as a reaction in which heterogeneous substances, when mixed together, and left to themselves to form combinations, whereby they do so such that they are influenced by a difference in quality rather than quantity. Moreover, when it is exerted in forming a mere union of two or more substances, it called *attraction of solution* or *fusion*, according as it is affected either in the moist or the dry way. This affinity type, according to Adler, is exemplified by the following passage: 'let me hurry on', said Charlotte, 'to see whether I understand what you mean. Just as everything must have a relation to itself, so it must also have a relationship to others. And that will vary according to the difference in their natures', Eduard quickly commented. 'Some will meet like old friends and acquaintances, who quickly come together and unite, without changing each other in any way, as wine mixes with water …'

Both affinity of aggregation and affinity of composition, during the 18th century, were often grouped under the category of 'simple affinities', as contrasted with

'complicated affinities'. The latter tended to involve multiple reactants and chemical decomposition, rather than simple mechanical decomposition.

The third type is *compound affinity* which works between the 'integrant parts', i.e. parts that can be divided mechanically, of different compounds to form a new compound. It was the force that unites the 'constituent parts of molecules' of a compound body.[99] In Goethe's novella, according to Adler, the model given to represent this type of affinity is the example of two substances which do not mix: 'whilst on the other hand, some substances will coexist like strangers, and cannot even be combined by mechanical mixing and rubbing; like oil and water which, after being mixed together, immediately separate again.'[101]

The fourth type is *mediating affinity* being that where one species or substance brings about an action in or between two other species or substances. Macquer gives the example of sulfur and water, which can be united through an alkaline salt, the 'mediator'. Oils and sulphur, for example, are insoluble in water, but by combining with the alkaline salts the change into soaps and liver of sulphur, and as such dissolve in water, whereby the alkaline salt acts as the 'intermediary'.[102] In the novella, the Captain says 'thus we combine … oil with water by means of an alkaline salt.'[103]

The person in the novella, who is obviously the mediating agent is Mittler the 'mediator' who, throughout the story, goes around or is attracted only to those situations in which there is some kind of conflict or dispute. He dissolves these various disputes in such a manner so as resultantly to make the stuck reactions go, proceed, or return to their normal happy pace. Moreover, he takes enjoyment in doing this. It is said that 'there were no divorces whilst he was in the job, as a cleric, and the local courts were never bothered by disputes and litigation from his district.'

The fifth type is *affinity of decomposition*, other wise known as 'single elective affinity', of the form of [10.1] through [10.3], in which one attractive species displaces another less attractive species, i.e. less attractive from the viewpoint of the bonded partner, in an involved union. Said another way, when a third principle has a far superior affinity with one of the two principles in combination, a total decomposition of the existing combination and the formation of an entirely new combination follows.[104] Macquer illustrates this with an acid, alkalis, metal reaction examples. In the novella, as mentioned, Goethe uses a standard test for limestone:

$$Acid + Limestone \rightarrow Gypsum + Water + Aerial\ Acid \qquad [10.21]$$

Or, according to the Captain, 'what we call limestone is more or less pure earth, intimately joined up with a delicate acid, which has become known to us in the form of air. If one places a piece of this stone into dilute sulphuric acid, the latter takes hold of the lime and together they will appear as gypsum; but on the other hand, that delicate, aerial acid will disappear. A division has taken place, and a new

combination has emerged. One even considers it justified to apply the word elective *affinity* here, since it really looks as if one relation had been choose in preference to another, as if one had been selected instead of another.'[105]

The sixth type is *reciprocal affinity*, is a situation where a substance first enters a relation with one, then later with another substance. Macquer defines this as those cases in which the contending affinities were nearly equal. The principle that had been separated from another could reclaim it under different circumstances.[99] Vitriolic acid, for example, can displace nitrous acid from niter to form vitriolated tarter with vitriolic acid. But nitrous acid could displace vitriolic acid from vitriolated tarter to form the original niter. To understand this tricky type of affinity, Bergman asks: 'does *a* expel *b*, and *b a* reciprocally, according to circumstances? Does *c* perchance expel *a*, while it always gives way to *b*?' To answer this question, he states that one must 'consult experiment, the oracle of nature, with due care and patience, and we shall doubtless find the proper clue to guide us out of this labyrinth.'

Goethe, after stating that the characters in the novella will 'conduct experiments with nature', uses the example where Charlotte, having been displaced by Ottilie, but then having found a union with the Captain, latter decides that she wants to reclaim her husband Eduard. To make this happen, however, she realizes that to do so she can only reclaim him under 'different circumstances', e.g. if Ottilie was sent away to live with their aunt.

The seventh type is *double affinity*, in which two compounds could exchange their four principles to form two new compounds.[99] This type of affinity was also defined, according to German chemist Johann Göttling, where 'if a compound $A + B$ comes together with another, $C + D$, they will exchange parts, and create two new bodies, $A + C$ and $B + D$.'[106] This is obviously the core affinity model as is found in the famous chapter four of *Elective Affinities*, where as we are told, by the Captain, 'imagine an *A*, which is intimately united with a *B*, and cannot be separated form it by various means or by force; imagine a *C*, united to a *D* in the same way; now bring the two pairs into contact: *A* will throw itself to *D*, and *C* to *B*, so that one cannot say which left the other one first, and which was the first to re-unite with another.[107]

Interestingly, these laws of affinity or 'attraction', are now part of the vernacular of the average person, even though they are somewhat hidden in the historical depths of chemistry.[108] Relationship experts, from speed dating to marriage, often invoke the so-called 'laws of attraction' in efforts to argue a point, give advice, or to outline a dating strategy. In 2006, relationship columnist Susan Davis, from the *Online Dating Magazine*, for example, states that 'of all the universal laws, the single most powerful law, is the law of attraction: that which is likened unto itself is drawn', or simply '*like attracts like*.' She argues that 'what one is focused on, manages to come to them' and that attentive goals and simple intention creates an attraction.[109] This is another way of saying that people with similar views, interests, and pastimes will

naturally attract or electromagnetate towards each other, whereas those opposite in such views will repel apart.

As to Goethe's novella, and how the laws of attraction mediated out in the story, we will leave it to the reader to see how this tale ends. Let it be said, however, that via this 1809 scientific masterpiece, although the mechanism of the human chemical bond was not detailed and although the full interpretation of the relationship between heat, work, chemical affinities, and chemical reactions was not fully elucidated, we might rightly call Goethe the 'founder of human chemistry'.

In the years to follow *Elective Affinities*, however, affinity chemistry became more complicated. Two main factors led to this transition, were the new sciences of chemical thermodynamics and quantum chemistry. In short, firstly in the year 1800 the battery was invented, this led to the discovery of the electron and then to the quantum revolution, which showed that chemical bonds about atoms and molecules are quantized in shape and energy; second, in 1824 the science of thermodynamics was born, this led to general replacement of the word 'force' for the word 'energy', which could come in various forms, such as kinetic energy, potential energy, internal energy, free energy, bound energy, and particularly 'work'. In sum, affinity was soon *measured* in terms of the work a system of reactive species was capable of producing and *described* in terms of the three-dimensional interactions of valence electrons, quantums, and the chemical bonds they formed. In the next chapter, we will continue in this direction by showing how the concept of 'affinity' transformed into the concept of 'free energy'.

11 – Affinity and Free Energy:

"It's not chemistry that determines
long-term love – it's thermodynamics."
Wild Bob – Internet Writer, 2003[1]

Human chemistry, as Goethe showed, is the study of basic reactions between people as they interact, bond, debond, evolve, and produce daily work-output according to their natural chemical affinities. That reactive human molecules which have a natural or mutual affinity will tend to bond in relationships is obvious; that human molecules which together produce a negative chemical free energy change in relationships will tend to bond is not so obvious. To alleviate this issue, here we will show how the older 17th and 18th century concepts of elective affinities, were modified by the 19th century science of chemical thermodynamics, then updated with the advanced 20th century science of quantum chemistry, to thus transform into the modern-day 21st century concept of quantum chemical 'free energy'.

To begin with, in the decisive years prior to the publication of Goethe's *Elective Affinities* and in the years to follow, affinity chemistry became more complicated. Several factors contributed to this transition. One was the invention of the battery in 1800 by Alessandro Volta. With this new tool, electrochemists were able to measure the electrical current and hence the work produced by various chemical reactions, thus giving an approximate measure of affinity. Second, assuming that the amount of heat released from a reaction was a measure of affinity, new experiments whereby heat could be produced by friction began to conflict with older more established heat theories that viewed heat as a type of hypothetical particle that could not be created nor destroyed, going by various names such as terra pinguis, phlogiston, or caloric. Another complicating factor was the newly developing theory of chemical valency or 'combining power', which showed that affinities formed bonds between elements that were specific and directional.

A significant turning point in the development of affinity chemistry was 1797, when American physicist Benjamin Thomson, a cannon manufacturer in Munich, demonstrated that, through the use of friction, it was possible to convert work into heat. To do this, he designed a specially shaped cannon barrel, thoroughly insulated against heat loss, then replaced the sharp boring tool with a dull drill bit, and immersed the front part of the gun in a tank full of water. Using this setup, to the amazement of his onlookers, he made cold water boil in two-and-half-hours time, without the use of fire.[2] The results of this interesting experiment were in direct

conflict with Antoine Lavoisier's famous 1787 *caloric theory*, which argued that 'caloric', a fluid-like indestructible particle, was the cause of heat, which penetrated all bodies and dilated them by separating the atoms and molecules of bodies through the force of repulsion, thus diminishing their attractions or affinities.

Similarly, after 1800, with Alessandro Volta's invention of the battery, chemists were able to split bonded chemical species into parts via *electrolysis*, a method of separating bonded elements and compounds by passing an electric current through them. Hence, chemists were now able to study the internal structure and electrical attraction powers of chemicals. This led to the discovery of valency, or of preferred bond numbers and bond directions, in atoms and molecules. Moreover, this new power source allowed chemists to discern various 'electroaffinities' in elements, whereby *electronegative* elements, i.e. those that tend to gain electrons to form negative ions, attract or have affinity for *electropositive* elements, i.e. those that tend to lose electrons to form positive ions.

In modern terms, the *electron affinity* A_e is the energy change that occurs when an atom or molecule gains an electron to form a negative ion. In particular, for an atom or molecule X, it is the energy released for the electron-attachment reaction:[3]

$$X(g) + e^- \rightarrow X^-(g) \qquad [11.1]$$

Often this is measured in electronvolts; alternatively, the molar enthalpy change ΔH is used. In human chemical terms, [11.1] shows, in approximation, that basic human affinities will correlated with the a specific amount of energy released during any human-human attachment reaction, such as [1.1], and that these human affinity values will correlate with basic measures of enthalpy change.[4]

The central experiment that led to the development of the theory of the electron was English physicist Michael Faraday's 1838 discover of cathode rays. Through studies of these rays, in the century to follow, electrons (1897), light photons (1905), and orbital quantization (1913), were soon discovered and this soon naturally enough led to the development of a quantum mechanical picture of affinity. In 1927, for example, German physicist Walter Heitler used Schrödinger's wave equation [8.18] to show how two hydrogen atom wavefunctions can join together, with plus, minus, and exchange terms, to form a covalent bond. In this case the affinity felt between the two hydrogen atoms is explained in terms of quantum mechanical effects related to electron-nuclei-photon stabilities. In sum, after 1838 the idea of affinity as a measure of the 'force' that causes chemical reactions needed to find reconciliation with the new theories of heat, exchange forces, and quantum orbitals.

Nevertheless, even during the writing of *Elective Affinities*, Goethe was well aware of many of these new affinity difficulties related to electrical developments and frictional heat theories. A case in point, eight years prior to the publication of

Elective Affinities, in 1801, French chemist Claude Berthollet refuted the standard theory of affinity by arguing that 'simple elective attraction', of the form:

$$AC + B \rightarrow AB + C \qquad [11.2]$$

may exist, in actuality, such that a substance *A* could be divided between two others:

$$AC + B \rightarrow A1B + A2C \qquad [11.3]$$

This would have made little sense to Goethe. In other word, how could one human chemical species, i.e. one person, be divided in two?

In a conversation with his secretary Riemer dated September 26, 1826, Goethe mentions the fact that 'for decades' he has been struggling 'with Berthollet in the matter of the affinities'. Moreover, in the novella, Goethe subtly acknowledges his lack of understanding of these new theories of Berthollet. When the Captain and Eduard are discussing the theory of affinity, we are told that the Captain will explain affinity as 'I [he] learned from reading about it some ten years ago'. Taken literally, this would date the Captain's knowledge to the time just before Berthollet's main findings appeared, i.e. to the years around 1799. 'Whether it still fits the newer doctrines', the Captain adds, 'I am unable to say.' This proviso signals a divergence between the Captain's knowledge and the narrator's awareness that newer theories had begun to appear.[5]

At the core of this transition to the newer theories of affinities, was the newly developing concept of 'energy', which was beginning to replace the older theories of force.[6] We now view heat as 'energy in transit', but in Goethe's time this was not the case. Through observations of natural processes, such as boiling, one will note that heat tends to generally cause or force bodies to expand. Said another way, heat decreased affinities between the particles or constituents of bodies. So obvious was this phenomena, that Lavoisier defined 'the separation of particles by heat' as a constant and general law of nature.[7] By heating ice, for example, a large volume of water will result; by heating water, an even larger volume of vapor will result. Likewise, it was noted that heat was typically released during chemical reactions.

In Berzelius' 1814 book *Theory of Chemical Proportions*, for instance, he states this phenomenon as follows: 'experience shows that heat is disengaged in every chemical combination when carried out in circumstances favorable to its perception, and that by the saturation of powerful affinities, the temperature often rises to the point of incandescence, whilst the satisfaction of the feeblest affinities is capable of only raising the temperature through a few degrees.' The definition of what the nature of heat technically and how heat related to the measure of chemical affinity, however, was changing rapidly during these years.

Heat and affinity

Over the course of over two-thousand years the theory of what specifically heat was and how this related to affinity transformed from the old four element theories of the Greeks, in which heat was a form of fire, one of the basic elements, to the modern day conception in which heat is a form of energy in transit. Between these two points, there were several transitions junctions along the way, in which, during each step, the view of what heat was changed gradually.

In c. 350 BC, Aristotle, in his *Physics*, stated that there were four elements out of which all was made: earth, air, water, and fire. Building on this theory, in c. 790 Arabian chemist Jabir ibn-Hayyan (Geber) postulated that metals were formed out of two elements: *sulphur*, 'the stone which burns', which characterized the principle of combustibility, and *mercury*, which contained the idealized principle of metallic properties.[8] Shortly thereafter, this evolved into the Arabic concept of the three principles: *sulphur* giving flammability or combustion, *mercury* giving volatility and its opposite, and *salt* giving solidity.

In 1524, Swill chemist Paracelsus adopted Aristotle's four element theory, but reasoned that they appeared in bodies as Geber's three principles. Paracelsus saw these principles as fundamental, and justified them by recourse to the description of how wood burns in fire. Mercury included the cohesive principle, so that when it left in smoke the wood fell apart. Smoke represented the volatility (the mercury principle), the heat-giving flames represented flammability (sulphur), and the remnant ash represented solidity (salt).[8]

In 1669, German physician and chemist Johann Becher published his *Physica Subterranea*, in which, in modification on the ideas of Paracelsus, he argued that the constituents of bodies are air, water, and three types of earth: *terra fluida*, the mercurial element, which contributes fluidity and volatility; *terra lapida*, the solidifying element, which produces fusibility or the binding quality; and *terra pinguis*, the fatty element, which gives material substance its oily and combustible qualities.[9] These three earths correspond with Geber's three principles. A piece of wood, for example, according to Becher, is composed of ash and terra pinguis; when the wood is burnt, the terra pinguis is released, leaving the ash. In other words, in combustion the fatty earth burns away.

In 1703, a student of Becher's named Georg Stahl, a newly trained chemist and physician, modified his mentor's three earths theory by renaming terra pinguis as *phlogiston* from the Ancient Greek *phlogios* for 'fiery'.[10] Phlogiston was a name that had been used in the same sense previously by Nicolaus Hapelius (1606), Daniel Sennert (1619), and Jan Baptista van Helmont (1625).[7] Phlogiston, according to Stahl, is the 'matter and principle of fire, and not fire itself' that escapes from burning bodies with a rapid whirling motion, and is contained in all combustible bodies and also in metals, which can be burnt to 'calces'. Calx is a residual

substance, sometimes in the form of a fine powder, that is left when a metal or mineral combusts or is calcinated due to heat. Calx, especially of a metal, is now properly defined as an 'oxide', i.e. a chemical compound containing an oxygen atom and other elements. In the phlogiston theory, the calx was the true elemental substance, having lost its phlogiston in the process of combustion. The important point to note in Stahl's theory is that phlogiston can be *restored to the original substance* by supplying a replacement phlogiston from any material containing it, such as oil, wax, charcoal, or soot, which was thought to be nearly pure phlogiston.[9] This latter point, about restoring the phlogiston, was used by French physicist Sadi Carnot in the preliminary construction of the second law of thermodynamics.

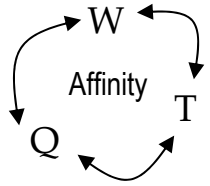
Phlogiston was thought of as a material entity, sometimes considered as the matter of fire, sometimes as a dry earthy substance (soot), sometimes as a fatty principle, such as in sulphur, oils, fats, and resins, and sometimes as invisible particles emitted by a burning candle. It is contained in animal, vegetable, and mineral bodies, and is the same in all. It could be *transferred from one body to another*.[9] This was another salient point that Carnot incorporated in the construction of the second law of thermodynamics.

One of the difficulties with Stahl's theory was that a calx becomes lighter when reduced to a metal by taking up phlogiston. If the phlogiston had mass, then when added to something, it should make it heavier. To remedy this issue, in an experiment published in 1786, French chemist Antoine Lavoisier proved that the matter of heat is weightless. Specifically, phosphorus burnt in air in a closed flask, with no appreciable change in weight.[9] Moreover, in the year to follow Lavoisier replaced Stahl's phlogiston theory with the *caloric theory*, which supposed that the matter of heat was an elastic, fluid-like, substance called 'caloric', whereby the sensation of warmth was the accumulation of this substance in the interstices of the particles of matter. In short, Lavoisier defined *caloric* as 'the repulsive cause, whatever that may be, which separated the particles of matter from each other.'[7] The caloric essentially replaced the phlogiston.

To compound this issue, as mentioned, was Benjamin Thomson's 1797 cannon boring experiment, which showed that by the use of friction created by boring cannons it was possible to convert work into heat. This conflicted Lavoisier's theory. In other words, how could one produce caloric particles by boring a cannon?

Likewise, in 1799 English chemist Humphry Davy discovery that by rubbing cubes of ice together, in a room colder than the freezing point of water, produces heat and causes melting. In conclusion of this result, which essentially disproved Lavoisier's caloric theory, he established the following proposition: 'the phenomena of repulsion are not dependent on a peculiar elastic fluid for their existence, or caloric does not exist.' He concludes that heat consists of a motion excited among the particles of bodies. 'To distinguish this motion from others, and to signify the cause of our sensation of heat,' and of the expansion or expansive pressure produced

in matter by heat, 'the name *repulsive* motion has been adopted.'[11] Other inconsistencies, such as Joule's 1843 paddle wheel experiment, which showed that a portion of the work energy *W*, obtained from the fall of a weight through a height, that went into turning the paddle wheel was converted into heat *Q* that functioned to increase the temperature *T* of the water in a measurable manner, were cropping up during this period such that heat was beginning to be seen as a form of *kinetic energy*, i.e. energy of matter related to the motions of its constituent particles.



In general, kinetic energy can be defined as the vibrational, rotational, or transitional energy possessed by an atom, molecule, or substance and quantified as the work that will be done by the body possessing the energy when it is brought to rest.[3]

In 1824, however, Sadi Carnot remedied these issues, to a certain extent, when he utilized a tricky combination of Stahl's theory, that phlogiston can be *restored* to the original substance, such as by putting the hot working body of a substance in a cylinder in contact with a cold reservoir thereby allowing the system to restore to its original state, and that heat can be *transferred* from one body to another, such as to pass the caloric particles from a hot body to a cold body, and Lavoisier's theory, that caloric causes particles to separate from one another, such as in the cylinder of a piston, along with some of the newer kinetic energy theories, e.g. by defining *work* or motive power in terms of the useful effect that a motor is capable of producing, which can be likened to the elevation of a weight to a certain height, to outline the original version of the second law of thermodynamics, as follows:[12]

> "The production of motive power in heat engines is due not to an actual consumption of the caloric, but to its transportation (transfer) from a warm body to a cold body, that is, to its re-establishment (restore) of equilibrium."

In sum, by virtue of these historical foundation precursors of heat theories, namely that the conception of heat evolved from that of *fire* (c. 350 BC), to *sulphur* (c. 790), to *terra pinguis* (1669), to *phlogiston* (1703), to *caloric* (1787), to *kinetic energy* (1797), Carnot essentially argued that engine cycles occur when heat particles are passed cyclically, i.e. first in a forward direction and then in a reverse direction, through the interstices of the working substance, thereby changing the affinities of the constituent particles comprising the working substance, such that expansion and contraction work is produced. However, he reasoned incorrectly, in a footnote, that

no change occurs in the substance of the working body, during each cycle. In the correct manner, the change is that of 'irreversibility', later formulated in terms of entropy [3.8] by Clausius beginning in 1850.[13]

Moreover, in this argument, Carnot assumed that heat, like a substance, cannot be diminished in quantity and that it cannot increase. Specifically, he states that in a complete engine cycle 'that when a body has experienced any changes, and when after a certain number of transformations it returns to its precisely its original state, that is, to that state considered in respect to density, to temperature, to *mode of aggregation*, let us suppose, I say that this body is found to contain the same quantity of heat that it contained at first, or else that the quantities of heat absorbed or set free in these different transformations are exactly compensated.' Furthermore, he states that 'this fact has never been called into question' and 'to deny this would overthrow the whole theory of heat to which it serves as a basis.' This famous sentence, which Clausius spent over fifteen years thinking about, marks the start of thermodynamics and signals the slow transition from the older caloric theory to the newer kinetic theory, in which heat is a type of energy in transit.[14]

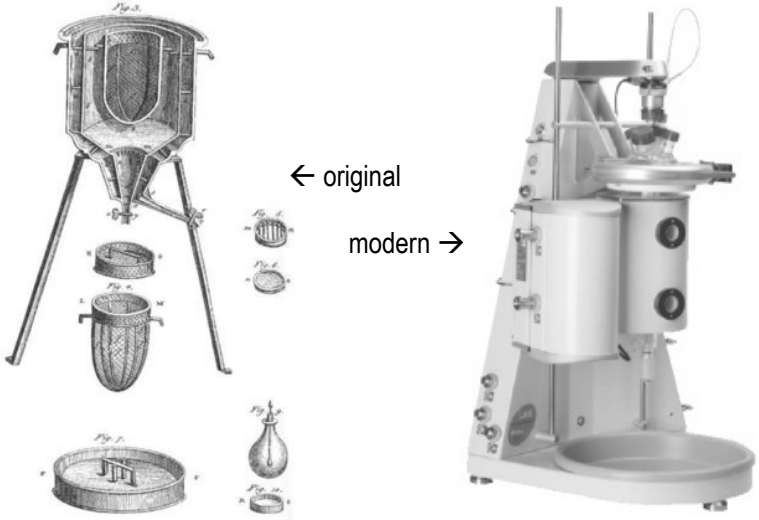
This transition had a marked effect on the various chemical affinity theories. In short, the older caloric-like theories assumed that when chemical reactions occurred, the particles or species newly put in contact attracted each other by virtue of their mutual affinities, whereby, as a result, they worked to squeeze out the 'caloric' particles, from between their pores, thus releasing heat and light in the process. Subsequently, it was reasonably argued, that by measuring the heat released from various reactions one could correlate this to a measure of chemical affinity. Thus, according to this logic, heat release was thought to be a direct measure of affinity. Yet, after 1924, with the transition from the caloric theory to the kinetic theory, this heat measurement theory of chemical affinity needed an overhaul.

In short, following Rudolf Clausius' 1854 formulation of entropy, attempted measurements of chemical affinity, via calorimetry measurements or according to the electricity and heat produced in half-cells, began to encounter conceptual and theoretical difficulties. Namely, if affinity was indeed related to the heat released or electricity produced by chemical reactions, then a calculation of this measure would need to incorporate, in some way, the bound energy *'TS'* of the system, i.e. the proportion of internal intermolecular work energy that cannot be measured as external work.

Subsequently, in the beginning of the 19th century, the first major theoretical impediment to the further development of affinity chemistry was the conflict between new science of thermodynamics and older thermal theories of affinity that were gaining ground. Some, during these years, would often mix the two concepts of energy and affinity together. In 1861, for example, Michael Faraday stated that chemical affinity is 'the force of chemical action between different bodies' and that it

'depends entirely upon the energy with which particles of different kinds attract each other.'[15]

On a different front, the new science of thermochemistry was coming into its own. In 1782, French chemist Antoine Lavoisier and French mathematician Pierre-Simon Laplace founded the science of *thermochemistry* by building the world's first *ice-calorimeter*; a device used for measuring the heat of chemical reactions, physical phase changes, and heat capacities:



Lavoisier and Laplace's 1782 *ice-calorimeter* and a modern *reaction-calorimeter*

They used it to determine the heat evolved in various chemical changes; calculations which were based on Joseph Black's prior discovery of *latent heat*, i.e. the amount of energy in the form of heat that is required for a material to undergo a change of phase, such as liquid to vapor.[16]

The basic calorimeter consists of a thermometer attached to a fluid bath in an insulated container according to which a change in temperature can be measured in the contiguous fluid when a reaction takes place in the reacting system. In a constant volume process, in thermodynamic terms, the heat released from the reaction equals the change in the internal energy of the system:

$$Q = C_V \Delta T = \Delta U \qquad [11.4]$$

where C_V is the heat capacity at constant volume, which is a constant that varies per substance, being equal to the heat supplied to an object or specimen to its consequent rise in temperature. To elaborate, heat capacity, a term originating through the work of Scottish physician and thermochemist Joseph Black who used the phrase 'capacity for heat', which is generally measured at either constant volume or constant pressure, is the quantity of heat required to raise a unit of mass of substance one unit in

temperature along a specified path, provided that during the process no phase or chemical changes occur.[99] In equation form, heat capacity, or 'thermal capacity' as it is sometimes called, is defined as:[48]

$$C = \frac{dQ}{dT} \qquad [11.5]$$

In chemical reactions where pressure is kept constant, the heat measured represents the enthalpy change for the reaction:

$$Q = C_P \Delta T = \Delta H \qquad [11.6]$$

where C_P is the heat capacity at constant pressure. In most calorimetric work, the pressure and not the volume is kept constant.

A modern *reaction calorimeter*, is any instrument that enables the energy being released or absorbed by a reaction to be measured. There are many types of modern calorimeters. Those such as basic heat balance calorimeters, differential scanning calorimeters, isothermal microcalorimeters, titration calorimeters, and accelerated rate calorimeters are among the most common types.

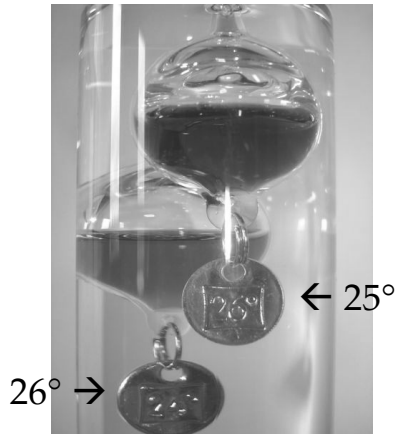
In simple terms, to find the enthalpy change ΔH per mole of a substance in a reaction between two liquids, X and Y, first the liquids are added to the calorimeter, then the initial and final fluid temperatures, after the reaction has finished, are noted. Multiplying this temperature change ΔT by the mass and specific heat capacities C_P of the liquids gives a value for the energy given off or absorbed during the reaction. Dividing the total energy change by the number of moles of species present gives the enthalpy change for the reaction.

Heat balance calorimetry, for instance, uses the temperature difference of the recirculating fluid within the reactor jacket to measure the heat loss from the system, whereby the heat released or absorbed from the reaction is:

$$Q = m_f C_p \Delta T \qquad [11.7]$$

in which m_f is the mass of the fluid, C_p is the heat capacity (at constant pressure) of the fluid, and ΔT is the heat loss or gain from the fluid, usually equal to $T_{out} - T_{in}$.

The design of *human reaction calorimeters*, i.e. devices to measure the heat loss or gain of human thermodynamic systems is an area of future research. To make such a device, equivalent to those described above for small laboratory reactions, one must first design human molecular thermometers. To elaborate, the first written record of a thermometer was made by Italian physiologist Santorio Santorii, who in 1612 put a 'scale' on Galileo's thermoscope (1600s):



Close-up section-view of a Galilean thermoscope

The basic *thermoscope*, is a sealed vertical glass cylinder, about a foot in height, which contains a clear fluid, such as water, within which float various sealed glass bulbs, each containing a different colored liquid. As the clear liquid in the cylinder changes temperature, due to the absorption of heat, i.e. energy in transit from the surrounding atmosphere, its density changes and those bulbs which are free to move, rise or fall to reach a position where their *density*, i.e. mass divided by volume, is either equal to that of the surrounding liquid or where they are brought to a halt by other bulbs. If the bulbs differ in density by a very small amount, and are ordered such that the least dense is at the top and most dense at the bottom, they can form a temperature scale.

Temperature, by definition, is the measure of the ability or tendency of a system to spontaneously give up energy. In the mercury thermometer, for example, when the tip of the thermometer is put in contact with a system, such as a pot of boiling water, energy in the form of heat flows from the hot system to the liquid system of mercury atoms, this causes an volume expansion in the mercury atom system, and as such the level of the top of mercury column rises per degrees of mark on the measurement scale drawn on the side of the glass of the thermometer tube. In a sense, in this example, the system of mercury atoms absorbs a portion of the energy of the water molecules, as per the zeroth law of thermodynamics, which forces the mercury atoms to do expansion work as they increase their volume against the force of atmospheric pressure.

Hence, to make a human reaction calorimeter, one needs firstly a *human system thermometer*, equivalent to those described above, i.e. a device to measure the ability or tendency of a human system to spontaneously give up energy. This is a very deep problem, the theoretical intricacies of which are not realized on first pass or even after many passes. The basic mercury thermometer, for example, will always give body temperature and ambient atmospheric temperature readings of approximately 98° and 77° F, respectively, regardless of the various changes in the energetics of the

human chemical reaction involved. As such, basic thermometers are of little value in the study and calculation of human reaction heat flow or enthalpy changes.

To give a very rudimentary example, supposing one had in their possession a functioning human system thermometer, then to measure a human reaction enthalpy change, using a hypothetical human reaction calorimeter, the human chemist would first situate an insulated system of reacting humans, e.g. a husband and a wife in a room working on a project together, in a reaction vessel. To measure the *heat*, i.e. energy in transit, released or absorbed from this reaction, the human chemist could then, for instance, send a fluid stream of flowing coolant human molecules through, adjacent, contiguous, or connected in some way (through interaction) to the reacting system, such that the stream, similar to the surrounding water stream used in modern reaction calorimeters, was able to absorb or give up energy to the reacting system. In this manner, the initial temperature T_{in} of the inlet human molecules would be measured and this would be compared to the outlet temperature T_{out} of the out flowing human molecules leaving the device. Next, the human chemist would need to calculate the heat capacity at constant pressure C_p of the flowing coolant human molecules. With these measurements, one could then obtain a crude measure of enthalpy change ΔH via equations [11.6] and [11.7] or possibly a modification of these equations. A reacting couple in a fluid or functioning marriage would invariably give energy up to the coolant stream, whereas a fighting couple in a locked-up, near-divorce, or non-functioning marriage would likely absorb energy when put in contact with the stream of human molecules and as such each stream would invariably have a different outflow temperature, i.e. being energized or down, respectively.

In any event, returning to our historical development, Lavoisier and Laplace showed that the heat evolved in a reaction is equal to the heat absorbed in the reverse reaction and investigated the specific heat and latent heat of a number of substances, and amounts of heat evolved in combustion. In 1777, Lavoisier went further by elaborating on the molecular constitution of bodies contingent upon the interplay of heat Q and affinities A. To explain the phenomenon in which heat causes a volume increase and cold a volume contraction, he states 'the molecules of bodies do not touch, that there exists between them a distance that heat augments and cold diminishes.'[17]

Moreover, in a manner analogous to the later thermodynamic phrasings used by Helmholtz, Lavoisier defined 'combined heat' as the proportion of heat united to a body so that one could not remove it without decomposing it and 'free heat' as all the heat that was not engaged in combination. It was not completely free, however, because of the affinity that matter supposedly had for the heat. The constant and determined heat lost in phase changes reflected the heat that passed from the free state to the combined state.[18]

In his 1787 *Elements of Chemistry*, Lavoisier outlined a connection between affinity, inter-species energetics, caloric, equilibrium, and temperature: 'although we

are far from being able to appreciate all these powers of affinity, or to express their proportional energy by numbers, we are certain, that, however variable they may be when considered in relation to the quantity of caloric with which they are combined, they are all nearly in equilibrium in the usual temperature of the atmosphere.'[19] This fundamental statement was one of the precursors to Gibbs' 1876 *On the Equilibrium of Heterogeneous Substances*.

Similarly, in 1840 Russian chemist Germain Hess formulated the principle that the evolution of heat in a reaction is the same whether the process is accomplished in one-step or in a number of stages. This known as Hess's law.[20] With the advent of the *mechanical theory of heat* in the early 19th century, Hess's law came to be viewed as a consequence of the law of conservation of energy.[21]

In thermochemistry, the *Thomsen-Berthelot principle* was an hypothesis which argued that all chemical changes are accompanied by the production of heat and that processes which occur will be ones in which the most heat is produced. This principle was formulated in slightly different versions by the Danish chemist Julius Thomsen in 1854 and by the French chemist Marcellin Berthelot in 1864. This early postulate in classical thermochemistry became the controversial foundation of a research program that would last three decades.

This principle came to be associated with what was called the *thermal theory of affinity*, which postulated that the heat evolved in a chemical reaction was the true measure of its affinity. In other words, the thermal theory proposed that all chemical changes are accompanied by the production of heat and that processes which occur spontaneously will be ones in which the most heat is produced.[22]

This theory made the most sense from Lavoisier's point of view, i.e. through the logic of the caloric theory. According to the caloric theory, a theory that still had persuasive sway at least until the 1850s, when a chemical reaction occurred, the those chemical species with the most affinity were attracted to each other, i.e. they drew closer in spatial proximity. During the process of this spatial combination, the hypothetical fluid-like caloric (heat) particles were squeezed out, leaving in the form of heat (warmth or fire) and light. Hence if, for instance, for every two particles that combined, one caloric particle was emitted, then if one could measure the emitted caloric particles, such as by measuring the heat released in a colorimeter, then one would have a gauge of the affinity.

Later, in 1875, Berthelot outlined his 'principle of maximum work', which stated that all chemical reactions will tend to yield the maximum amount of chemical energy in the form of work as the reaction progresses. It was a postulate concerning the relationship between chemical reactions, heat evolution, and the potential work produced therefrom. Whilst this principle is undoubtedly applicable to the great majority of chemical actions under ordinary conditions, it is subject to numerous exceptions, and cannot therefore be taken as a secure basis for theoretical reasoning in the relation between thermal effect and chemical affinity. The existence of

reactions which are reversible on slight alteration of conditions at once invalidates the principle, for if the action proceeding in one direction evolves heat, it must absorb heat when proceeding in the reverse direction.

Berthelot's theory was essentially: 'every pure chemical reaction is accompanied by evolution of heat; and that this yields the maximum amount of work.' The effects of irreversibility, however, showed this version to be incorrect. This was rectified, in thermodynamics, by incorporating the concept of entropy. In 1876, in particular, through the thermodynamic works of Willard Gibbs, Hermann von Helmholtz and others to follow, the work principle was found to be a particular case of a more general statement, in that: for all thermodynamic processes between the same initial and final state, the delivery of work is a maximum for a *reversible* process. The principle of maximum work, essentially, was a precursor to the development of the concept of thermodynamic free energy.

In the newly developing field of electrochemistry, during the first half of the 19th century, using electrolysis, chemical analysis, and stoichiometric investigations, chemists had begun to find exact atomic formulas for different species. Moreover, using the battery to strip electrons off atoms and molecules, they had discovered *free radicals*, which are atomic or molecular species with unpaired electrons on an otherwise open shell configuration. Unpaired electrons are usually highly reactive, which means that radicals are likely to take part in chemical reactions.

Along these lines, in 1852 the *theory of chemical valencies* was proposed by English chemist Edward Frankland, as discussed, in which he combined the older theories of free radicals and 'type theory' with thoughts on chemical affinity to show that certain elements have the tendency to combine with other elements to form compounds containing 3, i.e. in the three atom groups (e.g. NO_3, NH_3, NI_3, etc.) or 5, i.e. in the five atom groups (e.g. NO_5, NH_4O, PO_5, etc.), equivalents of the attached elements. It is in this manner, according to Franklin, that their affinities are best satisfied. Each element was thus assigned with a specific 'combining power', which soon afterwards was called quantivalence or valency and valence by American chemists.[9] By the 1860s, chemists had developed two clearly different notions of affinity: the notion of absolute valency for each atom of a substance in organic chemistry and the notion of variable affinity subject to different physical conditions.[23]

In 1855, in an interesting paper, German physician and philosopher Ludwig Büchner published his famous treatise *Force and Matter*, in which he expounds on the view, similar to Goethe, that matter and force are inseparable and that the chemical affinities between humans are exactly the same as those between atoms and molecules. Matter and force, according to Büchner, are indestructible and can never be separated; when separate, they become abstractions: 'imagine matter without force, and the minute particles of which a body consists,' says Büchner, 'without that system of mutual attraction and repulsion which holds them together and gives form

and shape to the body; imagine the molecular forces of cohesion and affinity removed, what then would be the consequence?'[24]

Büchner reasons that the chemical affinities of atoms and molecules are basic manifestations of the anthropomorphic conceptions of love and hate. Specifically, 'just as men and women attract one another, so oxygen attracts hydrogen, and, in loving union with it, forms water, that mighty omnipresent element, without which no life nor thought would be possible.' Likewise, 'potassium and phosphorous entertain such a violent passion for oxygen that even under water they burn, i.e. unite themselves with the beloved object.'

In the 1860s and 70s, the view that heat was type of indestructible fluid-like particle, such as caloric, was loosing face. The newer energy theories which were to replace it, however, were still not solidified. Hermann von Helmholtz, for example, in his famous 1862 article 'On the Conservation of Force', stated that the older view of the nature of heat was that it was 'a substance, very fine and imponderable indeed, but indestructible, and unchangeable in quantity.' The newer view, according to Helmholtz, is that heat is a type of energy that can be transformed, such as into work, a principle discovered predominately by Humphry Davy, Sadi Carnot, and Rudolf Clausius, as is embodied in the first two laws of thermodynamics.[25]

The 1882 Helmholtz derivation

In the late 1870s, although many physicists had rejected the thermochemical theory of affinity, it still enjoyed support from the majority of chemists. Physicists such as Willard Gibbs, John Rayleigh, Carl Neumann, and Henri Deville viewed it to be theoretically primitive and argued that a newer theory of chemical thermodynamics was needed.[26] They pointed out, in particular, that the Thomsen-Berthelot theory rested on the first law of thermodynamics, while it ignored the chemical implications of the second law.

In 1869, German physicist August Horstmann, a former student of Hermann von Helmholtz, was the first to incorporate Clausius' newly developed thermodynamic theories into chemistry. In particular, he applied the concept of entropy to the study of the *sublimation*, i.e. a solid to gas transition, of ammonium chloride NH_4Cl and showed that the process followed the same laws as those involving the vaporization of a liquid. In short, he was the first to apply entropy to basic equilibrium processes and derived various thermodynamic relations for chemical processes.[27] Willard Gibbs, in 1873, as discussed, independently began his own graphical research in chemical thermodynamics; his resultant publications, at the time, however, made less of an impact than Horstmann's.[28] In 1875, English physicist John Rayleigh criticized the chemists for not recognizing the importance of entropy and the second law of thermodynamics and its incompatibility with the thermal theory of affinity.[29]

None of these publications, however, made an impact in the minds of chemists in the field of affinity chemistry. In 1882, nevertheless, Berthelot's work principle was disproved when German scientist Hermann von Helmholtz showed that the true measure of affinity was not given by the heat evolved in a chemical reaction but rather by the maximum work, or free energy, produced when a reaction was carried out reversibly.[30] In thermodynamics, a *reversible process*, or 'reversible cycle' if the process is cyclic, is a process that can be reversed by means of infinitesimal changes in some property of the system without loss or dissipation of energy.[31] A process that is reversible is one that neglects the non-canceling effects of the energy related to intermolecular work frictions; some processes, such as equilibrium reactions, can be modeled as being reversible.[32] A reversible process is also called an ideal process and does not exist in reality.

In human life, the fact that free energy, being a measure of the maximum work produced during a work cycle, is a measure of affinity, translates to the effect that the cumulative action of multitudes of attractions and repulsions, owing to inter-personal human affinities, will on average tend to actuate only those process or relationships which will 'work' the best, i.e. produce the most work-output; not necessarily those which will produce the most heat, i.e. be the hottest. Thomsen and Berthelot, on the contrary, had argued that the tendency of a reaction to occur was determined by the heat evolved in the reaction; the occurrence of known *endothermic reactions*, i.e. heat absorbing processes, however, negated their logic.[97]

To remedy these illogical issues, Helmholtz argued that instead of focusing on heat alone one should distinguish between two forms of energy, 'free' energy and 'bound' energy. Only the free energy can be converted into other forms of energy, such as work, or electrical energy, etc.; the bound energy is obtainable only as heat.[97] As such, according to Helmholtz, one should distinguish between the portion of energy that appeared only as heat and the portion of energy that could freely be converted into other kinds of work. This latter part Helmholtz called 'free energy'.[26]

Helmholtz's derivation rested primarily on the work of Clausius. In 1854, Clausius had stated, in a phrasing similar to Lavoisier's 'combined heat', that during a complete cycle there is a *Verwandlungsinhalt* or 'bound transformation content', which he denoted by the integral of dQ/T between T_1 and T_2, and which he later termed entropy, as defined by [3.16].[33] On this terminology, Helmholtz conceptually divided the portion of the total energy U available for conversion to other forms as 'free energy', G or F, and the residual 'bound energy', TS. The difference between the Gibbs and the Helmholtz equations, and those derived from them, is that the Gibbs free energy G applies to processes at constant pressure, while the Helmholtz free energy F refers to those proceeding at constant volume.

Prior to these theoretical developments, in the 1840s English physicist James Joule had postulated the view that 'voltaic heat' equals 'chemical heat'. For many years Helmholtz agreed with this logic, even going so far as to justify it based on the

conservation of force. In 1882, however, in his famous article *Die Thermodynamik chemischer Vorgange*, Helmholtz proved that the two fundamental functions of the thermodynamics of Clausius, namely *U* and *S*, could be replaced by a new function called the 'free energy' or:

$$F(T,V) = U - TS \qquad [11.8]$$

On this view, Helmholtz showed that chemical heat is not equal to voltaic heat, but rather ΔF is the true measure of chemical affinity. In his own words, 'given the unlimited validity of Clausius' law, it would then be the value of the free energy, not that of the total energy resulting from heat production, which determines in which sense the chemical affinities can be active.' Said another way, Helmholtz showed that if a system is maintained at constant temperature and volume, a reaction can only occur spontaneously if there is a decrease in the free energy, i.e. a decrease in the quantity of the total internal energy *U* less the bound energy *TS*.[97] Hence, free energy *F* or *G* is that part or the total or internal energy *U* that can be transformed completely into heat, electrical energy, mechanical energy, etc. In human terms, it is that portion of the total system energy that can be transformed completely into occupational energy, or 'evolution energy', as Gladyshev defined, or 'value energy', as Jung defined, etc. The transformation of the bound energy *TS*, in a system, is subject to the second law of thermodynamics. Bound energy is present in the form of heat.[34]

In short, Helmholtz outlined the view that isothermal changes can only proceed spontaneously in the direction corresponding to a decrease in the free energy. In human reaction terms, this translates to the fact that those relationships that occur *spontaneously*, i.e. arising from natural feeling or native tendency without external constraint, will be those reactions that will correspond to a decrease in the free energy. In addition, according to Helmholtz, any external work would take place at the expense of free energy, while heat production would result in a loss of bound energy. This led Helmholtz to conclude that the work performed by the free energies of a system determine the direction of chemical change.[26]

Gibbs, to review, had previous derived the same result early in 1873, where he used the term 'available energy', however, he did not qualify his results in regards to terms such as affinity or bound energy. Gibbs recognized that the function 'H – TS' has special significance, in that the condition for equilibrium at constant pressure and temperature is:

$$\Delta G = 0 \qquad [11.9]$$

In other words, the condition for a process to occur ***spontaneously*** is that the value of *G* must decrease, until finally at equilibrium it reaches a miniumum value.[97] This

was the central issue that Goethe dealt with in his *Elective Affinities*. According to a review of *Elective Affinities* by Penguin Classic Books, '*Elective Affinities* reflects the conflict which Goethe felt between the high regard for the idea of marriage and his experience of ***spontaneous*** passion.' In other words, Goethe sought to rectify the ideal of the immortal marriage bond with that of the laws of affinity (free energy), in that when a marriage is at equilibrium, it will not go anymore.

Two years following Helmholtz's affinity/free energy derivation, a proof that is too lengthy to include here, in 1884, Dutch physical chemist Jacobus van't Hoff published his *Études de Dynamique chimique*, i.e. *'Studies in Chemical Dynamics'*, the world's first textbook on both chemical thermodynamics and chemical kinetics. In the *Études*, vant't Hoff included a criticism of the conclusion reached by Julius Thomsen and Berthelot that the heat evolved is the driving force of a chemical reaction. He realized that the sign of Q influences only how the equilibrium constant K changes with temperature, but does not control its actual magnitude. At absolute zero, van't Hoff also noted that the Thomsen-Berthelot principle is correct, but not at other temperatures.[97]

In the *Études*, interestingly, aside from presenting new theories on chemical kinetics, e.g. a method for determining the order of a reaction using graphics, he applied the laws of thermodynamics to chemical equilibrium processes, and without recourse to the concepts of either free energy or entropy, yet he arrived at an expression for the work w_A of chemical affinity, nearly identical to that of Gibbs and Helmholtz.[97] In 1901, for his efforts, van't Hoff was awarded the first Nobel Prize in chemistry.

Following Helmholtz and van't Hoff, others such German chemist Walther Nernst (1887) argued similarly that the change in the free energy, i.e. the maximum work made available for external use by a reversible process, is a measure of the affinity or driving force of a chemical reaction.[35] This assignment, for many, was of great practical importance: once determined, the free energy associated with the formation of a substance from its elements might be used in other reactions in which that substance was a participant. In this manner, a table containing values of the free energy of formation of a relatively small number of substances could, with a little ingenuity, serve as an affinity table covering a vast number of chemical reactions.[36] The change in free energy, in short, was that quantity which had been sought since the time of Newton.

Similarly, a number of ways in which to measure free energy were beginning to appear. Gibbs had shown, in 1876, that free energy, in isothermal, isobaric systems, was equivalent to the enthalpy H of a system less the difference of the temperature T multiplied by the entropy S:

$$\Delta G = \Delta H - T\Delta S \qquad [4.11]$$

In 1884, van't Hoff had shown that the free-energy change, being equal to the work w_A of chemical affinity, accompanying a basic chemical reaction in the gas phase was related to the equilibrium constant K of the reaction and the partial pressures p of the reacting species:

$$\Delta G = RT \ln K - RT \ln\left(\frac{p_C^c p_D^d}{p_A^a p_B^b}\right) \qquad [11.10]$$

In 1889, Walther Nernst showed that the free energy change accompanying chemical reaction was proportional to the electromotive force generated by the reaction in a Voltaic cell:

$$\Delta G = -nF\Delta \mathcal{C} \qquad [11.11]$$

Here, n is the number of electrons transferred, F is the faraday, and $\Delta \mathcal{C} = \mathcal{C}_2 - \mathcal{C}_1$ is the standard electromotive force. This unique expression represented the fact that the electromotive force of a galvanic cell is a measure of the affinity of the current-generating chemical process. In 1906, to elaborate on this, Nernst published his 'the calculation of chemical equilibria from thermal measurements' in which he proved that in all cases, chemical affinity and the evolution of heat become identical at low temperatures. In other words, at absolute zero of temperature the entropy of the substance equals zero and via [4.11] the free energy change equals the heat released and hence it is a measure of the chemical affinity. This fact is known as the third law of thermodynamics.[37] For his thermochemical work and discoveries, Nernst won the 1921 Nobel Prize in chemistry.[38]

In summary of this heat, chemical affinity, free energy discussion, the work w_A of chemical affinity of spontaneous reacting systems is equivalent to the measure of thermodynamic free energy of the reaction, a fact that took over a millinium to figure out:[97]

$$w_A = -\Delta G \qquad [11.12]$$

In human chemistry, this translates to the effect that the work of relationships w_R of people who have a natural affinity for one another is quantified thermodynamically by the change in the Gibbs free energy of the reacting system. This is the concise definition of human affinity. Historically, however, following the work of Goethe, a number of individuals have applied 'verbal' qualifications of affinity and free energy in application and analysis of human life processes. The first to do this was German Max Weber.

Weber's sociological affinities

The first to use the concept of 'elective affinity' in social and economic theory was German economist and sociologist Max Weber.[39] Using Goethe's chemical theory of intimate and social affinities, Weber innovated a *social elective affinity* to conceptualize in nondeterministic fashion the coincident interaction of components from different sociocultural systems in comparative analysis.[40]

In 1878, at the young age of fourteen, Weber had written letters studded with references to Homer, Virgil, Cicero, and Livy, and he had an extended knowledge of Goethe, Spinoza, Kant, and Schopenhauer. Four years later, in 1882, Weber enrolled in the University of Heidelberg as a law student, similar to Goethe, and pursued advanced studies in the social sciences and economics.[41] He would later go on to publish a number of papers, thus becoming one of the founders of sociology.[42]

Although Weber used the term 'elective affinity' elusively throughout his works, the quintessential publication was his 1904 essay 'The Protestant Ethic and the Spirit of Capitalism.'[43] In this essay, according to Weber, there was an *elective affinity* between Puritan ethical norms and emerging capitalist business practices in seventeenth-century England; later theorists have extended this to include the political position of Puritan partisans. In other words, a particular economic status, political status, and religious practice all will coincide in such a way that each is especially favorable to the other, and the whole form a culture complex, i.e. a 'civilizational complex', that is especially powerful for the advancement of all of the sociocultural spheres combined.[40] Moreover, the conception of human elective affinities is not restricted to a single case, but rather it can be considered as a general theory of social change; that is, when the favorable coincidence of sociocultural spheres occurs, there can be a quantum leap forward or backward on the part of the sociocultural system.[40]

Some have described Weber's 1904 essay as one of 'complex affinity' in which a social relation was a temporal process beginning with an initial stage of mutual attraction, developing into a phase of dis-affinity in which the intellectuals modified the ideas in some manner, and terminating in still another stage of affinity, in which the group re-aligned its interests and life style to mesh with the now altered ideational element.[39] In general, historians agree that, owing to the perspicuous yet elusive use of Weber's elective affinities in social theory, he believed that the sole significant universal propositions that social science could make would be propositions of elective affinity, which would be to say that the very possibility of social science would rest on the logic of elective affinity.[44]

In sum, Weber used Goethe's elective affinity theories, not in an individual or personal reaction manner, but in more encompassing way where ideals, social rules, thoughts, political systems, etc., functioned in ways to create social complexes.

Affinity / free energy theories: 1910-1992

In American navel engineer William Fairburn's 1914 *Human Chemistry*, he stated that just as there are affinities among the chemical elements, so are there associative affinities among *human chemical elements* (people), which produce both favored and unfavored social combinations and work groups. Although Fairburn does not go so far as to state, along the lines of Helmholtz, that the work performed by the free energies of a human system determine the direction of chemical change, he does, as mentioned, correctly state that each human being can be quantified according to a measure of molecular or 'personal entropy', i.e. a value related to the bound energy '-TS' in a reacting system, similar to any other chemical species. In other words, according to Fairburn, those species with the greatest mutual affinities will produce the most work in the form of free energy, approximately.

In a 1912 lecture in Paris, Swedish chemist Svante Arrhenius told his audience that the central problem of chemistry remained that of 'affinity' or the 'cause of chemical reaction'[45] Interestingly, at the time one of Arrhenius' closest colleagues in Paris was physical chemist Jean Perrin. The direction of Perrin's research was on the problem of chemical activation energy E_A, inspired by the early radiation theory and quantum theory, as developed by Planck, Einstein, and Nernst. The best known of Perrin's work is his 1913 *Les atomes*, in which he defended the kinetic theory and physical atomism. In this publication, following a brief mention of Einstein's proposal that a molecule absorbs a quantum of energy when it undergoes a photochemical change, Perrin suggested that the absorption of radiation may be the key to the chemical destabilization of molecules.

In human molecular terms, the absorption of electromagnetic sensory radiation in the form of sight, hearing, taste, smell, touch, etc., likewise, as we have shown, is the key to the chemical destabilization of humans. Russian physical chemist Georgi Gladyshev, in his 1997 *Thermodynamic Theory on the Evolution of Living Beings*, was one of the first to state this fact implicitly. When referring to the well-known empirical law by Weber-Fechner, which describes the reaction of living objects to various external influences, he states:[98]

> "Indeed, light, acoustic and magnetic fields, mechanical torsions, smell, and psychological stresses *initiate the reaction* of biological objects and determine their behavior."

In other words, once human molecules receive the visual imprint, for example, of something insatiably desirable, such as the delectable sight a beautiful women or handsome man, or conversely of something of a mental aberration, as the sound of someone lying to us, the mental register or neurological storage of that information will tend to drive us in such a direction so to achieve dynamic stability in that sense.

Both Perrin and Gladyshev, subsequently, were well ahead of themselves with their theories. By the 1920s, Perrin's hypothesis had become radically bold: 'the essential mechanism of all chemical reaction is therefore to be sought in the action of light upon atoms.'[46] In other words, the actions of intermolecular affinities are, in a sense, activated or triggered via quantum or photonic inputs.

In 1922, building on the logic of Helmholtz, Belgian mathematical physicist Théophile de Donder, similar to van't Hoff, formulated a relation between chemical affinity A and Gibbs free energy G. De Donder showed that if we consider a mixture of chemical species with the possibility of chemical reaction, the measure of affinity felt between the reacting species is equal to the negative of the Gibbs free energy of formation ΔG for the reaction.[47]

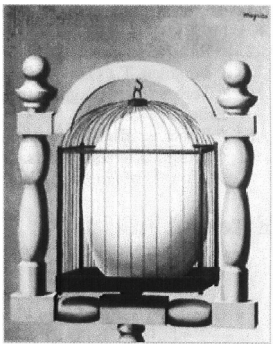
$$A = -\Delta G \qquad [11.13]$$

This connection was significant for chemists. Essentially, however, it was the same derivation done by Helmholtz forty years earlier for constant temperature, constant volume processes. Likewise, several years later, Belgian physical chemist Ilya Prigogine derived a similar expression for the electrochemical affinity of a chemical reaction performed in a galvanic cell.[48]

In 1923, American chemist's Gilbert Lewis and Merle Randall published their influential textbook *Thermodynamics and the Free Energy of Chemical Reactions*. In it, building on the works of Newton, Bergman, Gibbs, Helmholtz, de Donder, and others, and after studying and measuring Gibbs free energies of chemical species for a period of thirty years, they produced a cogent teaching-style outline on how Gibbs free energy calculations could be effectively utilized in chemist with great success.

Throughout the remainder of the 20th century, according to chemistry historian Henry Leicester, this famous publication led to the replacement of the term 'affinity' by the term 'free energy' in much of the English-speaking world.[49] Hence, it is now known that the thermodynamic quantity free energy, i.e. the energy portion of a reactive system available for useful work, is a more advanced and accurate replacement for the term affinity used by chemists, of olden days, to describe the 'force' that causes chemical reactions.

In 1933, Belgian surreal artist René Magritte executed a paradoxical painting entitled *Elective Affinities* to capture the one of the underlying issues in Goethe's novella, that of freedom:



René Magritte's 1933 oil on canvas painting ***Elective Affinities***

Magritte's painting elaborates on Goethe's view that although a person may, at times, feel free, he or she is always under the control of affinities or forces, over which they have no control.[50] The following quote by Goethe summarizes this view:

> "None are more hopelessly enslaved than those who falsely believe they are free."

In other words, a quick perusal of any standard affinity table will highlight the fact that chemical species are confined or rather predisposed to certain reactions. In human life, however, the translation of this chemical fact becomes more complicated and on certain points difficult to pin down, although the underlying message is still the same.

It is an inarguable fact that at certain points or windows in life a person may feel free as a bird and at other times trapped in like a mouse on a running wheel. More then this, from certain points of view, it can be argued that being trapped is a desired arrangement. In the 1988 book *The Bonds of Love*, psychiatrist Jessica Benjamin uses a type of Freudian logic to argue that we begin life with the conflict between dependence and independence in infant life, and then move outward toward the desirable opposites of power and surrender in adult sexual life. In addition, as Benjamin points out, Freud's vision of the conflict between instinct and civilization, this with its own dangers and drawbacks, has created an impasse for social thought. In other words, we repress various natural desires and instincts so to conform to the pleasantries of society. This type of societal domination through repression works to transform parts of the psyche, thus molding each person to various degrees. These perspectives, according to Benjamin, start us 'on a new approach to grasping the tension between the desire to be free and the desire not to be.'

In *Elective Affinities*, Goethe discusses an aspect of this 'freedom paradox' in relation to business. Business life and personal life, as a rule, according to Goethe, are to be kept separate. Business needs to have a certain seriousness and strict rule, but life, conversely, needs capriciousness. Goethe states that in business a person

must be thoroughly consequential, but in life a certain inconsequentiality is often called for and, in many cases, often delightful and heartening in its effect. Moreover, 'if you are secure in the first,' according to Goethe, 'you can *move all the more freely* in the second; whereas if you mix the two your freedom will carry your security away and end it.'

In recent years, Goethe's *Elective Affinities* has found application in movies and plays. In French new wave director François Truffaut's 1962 movie *Jules et Jim*, for example, the female in the love triangle, married to Jim, Catherine, was filmed while reading *Elective Affinities*, while Jules reunited with the couple after years of separation caused by WWI, hinting at the instability in her marriage. It was filmed in 1996 by director Paolo Taviani, as *Le affinità elettive*. It also served as the inspiration for the 1982 Francis Ford Coppola film *One from the Heart*.

One play in particular, that of the 1993 play *Arcadia*, is an excellent modern-day *Elective Affinities*, but with the incorporation of the effects of irreversibility, in terms of the second law of thermodynamics, among other newer scientific theories.

Arcadia and Elective Affinities

In 1993, British Playwright Tom Stoppard scripted a scientifically riddled, Goethe-influenced, modern-day, affinity-type thermodynamic play called *Arcadia*. In short, Stoppard scripted a story modeled on Goethe's 1809 *Elective Affinities*; it even takes place in the same year. *Arcadia* is set in Sidley Park, an English country house in the years 1809 and 1989 alternately, juxtaposing the activities of two modern scholars and the house's current residents with the lives of those who lived there 180 years earlier.[51]

Arcadia first opened at the Royal National Theatre in London on April 13, 1993, and has played at many theatres since. The critics were greatly impressed: the *Daily Telegraph's* critic wrote 'I have never left a new play more convinced that I'd just witnessed a masterpiece.' It won the 1993 Olivier Award for Best Play and the 1995 New York Drama Critics Award. A 1995 review of the play by the New Yorker stated that 'the caprices of history, like the accidents that become inevitabilities in a plot, are the charms of chance that Stoppard and the audience stand in awe of.' Moreover, according to this review:[52]

> "Life's terrifying randomness is a mystery that compels mankind to impose order. Chaos is psychologically intolerable; man's need for coherence is greater than his need for truth."

To give a quick summary of the play, in 1809, Thomasina Coverly, a 13-year-old mathematical genius fated to die before her 17th birthday, studies with her tutor,

Septimus Hodge, a friend of British poet Lord Byron, who is an unseen guest in the house. In 1989, a pair of competing academics, Hannah Jarvis, a writer, who is investigating a hermit, named Septimus Hodge, who once lived on the grounds, and Bernard Nightingale, a professor of literature, who is investigating the mysterious presence of Lord Byron in the house on April 10th of 1809, descend on the house. An interplay between these two years then follows. In sum, *Arcadia* is part detective story, part love story, part farcical comedy, with mathematics, literature, landscape gardening and chaos theory thrown in for good measure all set in two different centuries.

Just as Goethe's *Elective Affinities* is steeped in death, so to is *Arcadia*. The play's title is a reference to the Latin phrase *et in Arcadia ego* which translates that death is always present. The phrase 'Et in Arcadia ego', as quoted by Lady Croom, the archly witty resident aristocrat of Sidley Park in the 1809, first appeared in a 17th century picture by Guercino. It depicts a skull which has been found by shepherds, with an inscription which translates as 'Even in Arcadia there am I' [Death]. Lady Croom misinterprets the phrase to suggest a kind of utopian happiness, though Septimus later correctly ascribes its much darker aspect. The phrase resounds throughout the play, with a strong degree of poignancy.[53]

The theme of *Arcadia* is that it explores the nature of evidence and truth in the context of modern ideas about history, mathematics and physics. It shows how the clues left by the past are interpreted by scholars. The play refers to a wide array of subjects, including mathematics, physics, thermodynamics, computer algorithms, fractals, population dynamics, chaos theory vs. determinism (especially in the context of love and death), classics, landscape design, romanticism vs. classicism, English literature (particularly poetry), the work's of Lord Byron, 18th century periodicals, modern academia, and even South Pacific botany. These are the concrete topics of conversation; the more abstract philosophical resonances veer off into epistemology, nihilism, the origins of lust, and madness.[51]

One review by *American Theatre* critique Matt Wolf states the Arcadia aims for the head while writing for and about the heart. He states that 'moral philosophy, quantum mechanics, and even Fermat's last theorem' are discussed in such a manner that *Arcadia* is 'obsessed with explications of the world and the precepts that propel it.' The principles of chaos, the basic laws of thermodynamics, and even Thomas Newcomen's 18th century steam engine are discussed; and in association with these matters, the play's lasting impact 'lies in its piercing depiction of that other chaos: the lawless workings of love, sex, and death, which defy exact analysis.'[52]

The play's real topic is 'the attraction that Newton left out', as voiced by one of the characters Valentine Coverly, who functions as Stoppard's surrogate. This is a reference to Newton's views on chemical affinity, where as he says in the opening section of the *Principia*, 'I wish we could derive the rest of the phenomena of nature (chemistry) by the same kind of reasoning from mechanical principles (gravity)'. In

the play, the young Thomasina is similar to Goethe's young Ottilie, in that she throws the life of her tutor Septimus Hodge into permanent disorder when they begin to react together, just as Ottlie throws the life of Eduard into disorder. Similarly, in *Elective Affinities*, Ottilie is fated to die just as Thomasina is fated to die in *Arcadia*.

In the story, Stoppard plays on the thermodynamic phrase 'the action of bodies in heat'. To Thomasina and her tutor Septimus Hodge, the words suggest the entropic universe of the second law of thermodynamics and the collapse of classical mathematics. This is clearly an anachronism, since the concept of entropy wasn't yet invented in 1809. Nevertheless, to character Chloe Coverly, a distant descendent of Thomasina, those bodies, in a correct manner, are human beings and the heat is sexual.[54] Like particles, the house's visitors are constantly on the move.

In this manner, Stoppard parallels the second law of thermodynamics with the human experience in his play Arcadia. The parallelism suggests truths about the evolution of science and human society, love and sexual relationships, and the physical world. The second law of thermodynamics embodies one of the driving forces, i.e. *TS*, the 'enthalpic drive', in the evolutionary formation of more complex molecular structures in our universe, the diffusion of energy, such as heat, and is inhibited by the initial energy required to unlock potential energies of compounds. Stoppard takes these concepts and explores human genius and the sexual interactions of people, with an eye towards universal human truth.[54]

In 2001, literary reviewer Stella Copeland outlined an excellent thermodynamic analysis of Stoppard's *Arcadia*, in which, in her view, each human in the play is a complex molecule and where the laws of thermodynamics regulate the evolutionary interactions of these human molecules. Stoppard illustrates the diffusion of work and energy, according to Copeland, in comparison to human relationships by incorporating the theme of loss heavily in the play. There is loss of life, loss of knowledge and loss of love, or sexual energy, in Arcadia, as well as the scattering of characters that occurs in the first time period. It could be argued that Stoppard did not intend to imply thermodynamics with all of these elements of loss. However, the depth of this theme, its excellent correlation with thermodynamics, and the way in which it often appears adjacent to direct thermo-dynamical references, make a strong case for the parallel.[55]

The duality of life and death in relation to the first law of thermodynamics, i.e. the law of energy conservation, is a central issue in *Arcadia*. One of many prevalent references to death is the theme of hunting in the play. Thomasina notes, 'I have grown up in the sound of guns like a child of a siege.' The game hunting, all of those small animals dying as consequence, has been an enduring part of the Croom household. When the living energies of the grouse and the rabbits are lost, they can never be recovered in the same forms. In a later scene Septimus brings a rabbit for Thomasina, and Jellaby notes with distaste, 'It's dead'. Rabbits are symbols of vitality and energy. Septimus has made a rabbit cold by killing it. This repetitive

reference to the deaths of game animals implies the loss of heat and the scattering of personal energy in general. This is a central topic of *cessation thermodynamics*, i.e. the science of death and the moral conservation of the essence of a person in society in relation to the first law of thermodynamics (chapter sixteen).[56]

There are only three human deaths mentioned in *Arcadia*; the same is the case in Goethe's *Elective Affinities*. In *Arcadia*, of the three deaths, one, that of the hermit Septimus, relates little to the thermodynamic theme. One of the more significant is the death of Mr. Chater, bit by a monkey in the tropics. His death is not mourned by Lady Croom, who seems to feel the loss of his life energy was the better for her, 'We must be thankful the monkey bit Mr. Chater. If it had bit Mrs. Chater the monkey would be dead and we would not be the first in the kingdom to show a dahlia.' Her sarcasm is evident, but it seems that Mr. Chater's death may have in fact led to better organization, or at least to a bonding of Captain Brice and Mrs. Chater at the expense of Mr. Chater's life energy.[55]

Another poignant theme of loss is the essentially human experience of sexual passion, and the loss of that passion in the form of a lover. Stoppard illustrates this over and over again in the play. The characters, according to Copeland, collide in a multitude of different combinations. Like atoms, forming complex molecules, which is one of the consequences of the second law of thermodynamics. Chloe makes this parallel directly in the play: 'everything including us is just a lot of atoms bouncing off each other like billiard balls.' Indeed the actions of the characters seem to be like that. As they interact and bond, their sexual energy propels their interaction, and sometimes, that energy runs out. The reaction stops, and they break apart; the initial heat of their union is lost into the void of time.[55]

The activation energy needed to begin a reaction is another important chemical concept relating to the second law of thermodynamics. While energy has a universal tendency to disperse, 'It'll take a while but we're all going to end up at room temperature' as Valentine mentions, it is obstructed in this dispersal by chemical bonds. We can apply this to people by observing that sexual energy in particular often brings people together for a reaction. Heat can be the energy propelling the 'chemical Ladies' as Chloe says, and men together as we have already discussed, i.e. the action of bodies in heat.[55] This was discussed by Goethe in terms of the passions and physical proximities of the characters.

Stoppard extends all these references to thermodynamics with another aspect of the second law, being that the tendency for energy dispersion has in fact resulted in the formation of more complex molecules. At the beginning of time, after the big bang, there was lots of energy in the form of the simple components of atoms. These combined, and continued to do so, releasing energy in the process and adding to the general scattering of energy to create the complex molecules of life. Stoppard insinuates that in human interactions, despite the loss of life and love, culture continues to build in complexity. 'We die on the march. But there is nothing outside

the march so nothing can be lost.' As all the matter collides and reacts and gives off energy, so does he imply human science is mixing and moving forward with time irreversibly. 'The heat goes into the mix…and everything is mixing the same way, all the time irreversibly,' says Valentine.[55]

In this passage, Stoppard touches on the conflict that many have between the second law of thermodynamics, which is often paraphrased by the statement 'the entropy (disorganization) of the universe tends to a maximum' (a famous statement made by Clausius during a reading at the *Philosophical Society of Zurich* on the 24th of April, 1865), and the complexity increase found in association with evolution. The issue here, really, is that most people, for lack of better knowledge, focus on the tendencies associated with the entropy energy, *TS*, of an evolving system. This, however, is only one portion of a system's energy. The correct view is to study the evolution tendency of free energy *G*, a function that takes into account both the enthalpic *H* driving tendencies and the entropy *TS* driving tendencies of evolution, growth, and structural change.[57] Entropy is only have the picture.

The end of the play also connects the thermodynamic concept of chemical bonding and cooling with human knowledge through symbolism. The characters in both plays end up dancing. Their movement is resonant of the reactions of atoms, spinning forward in time. As Hannah dances away with the person who offered her knowledge, a poignant picture of the movement toward greater knowledge is formed. The teacher and the student, whose interactions produced the heat of love, and the heat of intellectual discovery, are dancing at the same time. Stoppard is drawing threads of thermodynamics and human behavior, especially passion and the pursuit of knowledge, together.[55]

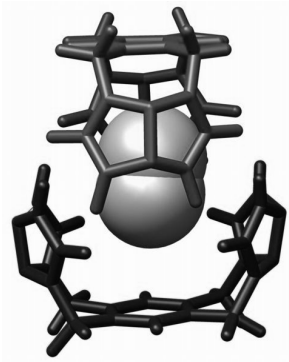
In summary of Arcadia, Copeland argues that Stoppard used the complex ideas of thermodynamics to explain the mechanics of the human experience, through heat as a metaphor for scientific and sexual passions. The author's theme of loss compares to the second law of thermodynamics which states energy's tendency to disperse.[58] He also uses people's sexual interactions to parallel chemical reactions, and scientific progress to parallel the second laws tendency to lead to more complex molecular structures. In other words, Stoppard, in his *Arcadia*, leads the audience through this interplay of sexual heating and cooling to say something profound about human knowledge in relationship to the interactions of human molecules. He wishes his audience to see that the progress of human understanding is a result of our passions in relationship to our reactions with each other. *Arcadia* asks us to see how natural human desire, i.e. affinity, fuels our growth as a species, despite the deaths of individuals.[55]

Arcadia, interesting, is now available as a 96-page book. It has a cover image, showing green summer fields, interspersed with rivers and lakes, near to a large house, duplicate to the image used on the cover of the Penguin Classics edition of Goethe's *Elective Affinities*, and is well worth the read.[59]

Modern affinity / free energy theories

In 1995, French Nobel Prize winning chemist Jean-Marie Lehn published the first-ever textbook on *supramolecular chemistry*. Being the world's leading expert on the subject of supramolecular chemistry, we are led through a breathtaking presentation into the world of the supermolecule.[60]

In supramolecular chemistry, a *supermolecule* is a well-defined discrete oligo-molecular species formed via intermolecular association of a finite number of atomic constituents or it can be defined as is a discrete complex of two or more molecules often macromolecules attached through non-covalent bonds. In biochemistry, a *supermolecule* is any very large complex molecule, such as oligonucleotides, RNA, or peptides, and are often composed of multiple strands; often found especially in plants and animals.[61] A supermolecule, a distant relative of the human molecule, is generally considered to be bigger in size, structure, and behavioral complexity than that of a macromolecule, neuromolecule, biomolecule, or molecule. A basic example of a supramolecular assembly of a host and guest is shown below:



A *guest* N_2 is bound within a *host* hydrogen-bonded capsule

In the opening section of his textbook, Lehn gives a subtle tribute to Goethe: 'beyond molecular chemistry, being based on the covalent bond, there lies the field of supramolecular chemistry, whose goal it is to gain control over the intermolecular bond. It is concerned with the next step in increasing complexity beyond the molecule towards the supermolecule and organized polymolecular systems, held together by non-covalent interactions.' He continues 'it is a sort of *molecular sociology*! Non-covalent interactions define the inter-component bond, the action and reaction, in brief, the behavior of the molecular individuals and populations: their social structure as an ensemble of individuals having its own organization; their stability and their fragility; their tendency to associate or to isolate themselves; their selectivity, their *elective affinities* and class structure, their ability to recognize each other; their dynamics, fluidity or rigidity or arrangements and of castes, tensions,

motions and reorientations; their mutual action and their transformations by each other.' Lehn has excellent views indeed.

Supramolecular chemistry, i.e. the science and study of super-large molecules, is a sort of evolutionary forerunner or close neighbor to that of human chemistry, i.e. the science and study of human molecules.[62] As such, in the future, many human reaction models will invariably follow out along the pre-established models found in supramolecular chemistry. In this manner, Lehn, with his molecular sociology descriptions, is writing in excellent form.

In 1998, Belgian Nobel Prize winning chemist Ilya Prigogine summarized the history of affinity when he stated that in the past 'as motion was explained by the Newtonian concept of force, chemists wanted a similar concept of driving force for chemical change? Why do chemical reactions occur, and why do they stop at certain points? Chemists called the force that caused chemical reactions *affinity*, but it lacked a clear definition.'[63] With the development of chemical thermodynamics, over the last two centuries, chemical affinity has found a clear definition in the Gibbs free energy equation. The measure of affinity felt between reactant species can now be energetically quantified. In Prigogine's own words:

> "All chemical reactions drive the system to a state of equilibrium in which the affinities of the reactions vanish."

To relate this principle to human reaction life, in the U.S only 38 percent of wedded couples say that they are 'happily married.'[64] Similarly, according to U.S. Census Bureau statistics, forty-three percent of marriages, between reacting human species, will end by the fifteen-year mark.[65] Moreover, seventy-five percent of all divorced people remarry, half of them within three years.[64] Debonding, detaching, or divorcing reactions are chemically defined, for example, as shown below, wherein a man *Mx* detaches from a relationship with a woman *Fy*, and they go their separate ways, owing to a predominance of physical, mental, and emotional repulsive forces:

$$MxFy \rightarrow Mx + Fy \qquad [11.14]$$

These 'divorce-points', from a chemical or energetic perspective, would indicate a window in time in which the overall affinity felt between the bonded pair, e.g. husband and wife or boyfriend and girlfriend, vanishes. In other words, according to [11.7] the measure of affinity A felt between a reacting couple decreases, overall, to nothing, i.e. $A = 0$. In this case, $\Delta G = 0$ and the reaction will not go any more. Such an 'equilibriated' relationship, as this, would be at what is known as *thermodynamic equilibrium*, in which no further useful work could possibly be obtained.[66] Such

reaction periods can be energetically and technically defined as non-evolving or dead relationships.[67] These decoupling points, in human reactions, arise whenever one bonded partner in a relationship, unconsciously, no longer has desire or affinity to make the relationship or marriage work.[68]

In other situations, the level of mutual affinity felt between a bonded pair $Mx \equiv Fy$ can be quite large, i.e. $A \geq 0$. As such, according to [11.13] the measure of the change in the Gibbs free energy for their working reaction is negative, i.e. $\Delta G \leq 0$. In this case, the reaction continues to proceed spontaneously:

$$Mx \equiv Fy \rightarrow MxFy \qquad [11.15]$$

In this manner, the couple tightens their bonding to each other and spends their reaction potential along the way in the form of functionable work, i.e. the reaction goes or, said another way, the relationship works. In other situations, in fact in most situations, there is a thermodynamic coupling factor that effects biological as well as human reactions. Some energetically poor reactions, i.e. those in which $\Delta G \geq 0$, such as when a wife is continuously drawn to a wife beater, can continue to react owing to external driving forces. This, however, is a more advanced topic.

In subjects such as biochemistry and pharmacology, a blend of chemical affinity and free energy theories still find applicable use. In American physician Robert Raffa's 2001 *Drug-Receptor Thermodynamics* textbook, for example, we find a plethora of affinity / free energy reaction models, which are analogs to human chemical reaction life. Some models of drug-receptor interactions, for instance, show that the chemical affinity of a *ligand* or binding molecule toward a *receptor* or binding site falls into an energy range of -10 and -80 kJ mol^{-1}. These values relate to a binding constant and correspond to a Gibbs free energy. Accordingly, enthalpic and entropic effects determine *binding affinity*.[69] This process, by extrapolation, is analogous to how, stereotypically, a single female human molecule migrates towards the stable bonding structure of a male human molecule together with his occupational environment and his living arrangements.

Keranis' social organization free energy theories

In the 2005 article 'Human Values and the 2nd Law of Thermodynamics', by Greek Lawyer and philosopher Dimitris Keranis, we find a well-written take on purposeful action in relation to the Gibbs free energy function.[70] In this article, Keranis argues that nature's inherent tendency to organize itself through the production of work is quantified by Gibbs free energy [4.9]. The tendency of systems to organize through the production of work, according to Keranis, is responsible for the 'flow of energy within the social system' and that all economic activity can be reduced to these organizational acts. Social acts such as speech, poetry, fine arts, for example,

translate, similar to Jung's value/energy theory, into 'value flows' within the system. When conceived as social dispersal structures, these acts reflect a natural tendency to diminish the intensity and to 'downgrade the capacity of energy to produce work'.

Here, Keranis is referring to the evolution tendency of social systems to follow the governing rule of combined law of thermodynamics [4.27], in which each social structure or system will evolve, i.e. increase in complexity, as it seeks equilibrium, thus reducing its chemical potential along the way. To elaborate further, Keranis states that the linkage between the flows of economic acts and flow of values, leads to the conclusion that in social systems, production of work and entropy depend on two antithetically opposed factors, i.e. acts and values, and that this relationship is expressed by the Gibbs function, i.e. $G = H - TS$, where the enthalpy energy H and entropy energy TS are the 'two opposing forces in the production of work.'[70]

Moreover, Keranis argues that in economic terms, the relationship between the flow of economic acts and the flow of values is captured by *Zolotas' function*, an expression that relates economic growth to social welfare, which was developed by Greek social economist Xenophon Zolotas, as presented in his 1981 book *Economic Growth and Declining Social Welfare*.[71] In his book, Zolotas built on the thermoeconomic theories of Romanian mathematician Nicholas Georgescu-Roegen who previously in his 1971 *The Entropy Law and the Economic Process* had laid out the view that the amount of energy bound within a closed system continuously increases; where, as a result, there is a gradual shift from low entropy (large free energy) to high entropy (large bound energy). The thermodynamic balance of such a system, according to Zolotas, is restored when 'all the free energy is converted to bound energy.' The effects of the law of entropy in relation to economic growth, according to Zolotas, 'can best be understood if the world ecosystem is conceived as a closed system, in which one of the links is human economic activity'.

Although Zolotas, as we see, is stabbing in the correct direction, his downfall in logic is that he reasons that the free energy in question refers to energy stored in the natural fuels, e.g. coal, oil, wood, etc., rather than the (bonding) free energy that is released through reactions between humans. To exemplify, Zolotas states 'it can be seen that the function of industrial development is to convert rapidly the valuable and finite stock of free terrestrial energy (low entropy), into bound energy (high entropy).' In this manner, Zolotas is viewing the situation in the wrong perspective. Fuels such as coal and oil, although limited, are merely catalytic substrate mediators, i.e. they only facilitate the speed of the reaction, by lowering the activation energy barrier of human reactions, but play little role in the thermodynamic calculations of human reaction free energies.

To elaborate on his illogic further, he states 'if it were eventually possible for man to put to use other forms of energy flows (solar, Aeolian, etc.), which by their nature are virtually unlimited, the entropy law would be practically irrelevant, since the economic process would occur as part of an open system.' This is clearly a

misstatement. In the correct manner, the second law of thermodynamics is always relevant. It is one of the only two driving forces in life.

In any event, Keranis uses this outline as a criterion for determining optimum *equilibriation rates* in social systems. To arrive at his theory, Keranis studied the concept of entropy for a number of years as it is presented in the science of thermoeconomics in relation to the second law of thermodynamics in an attempt to relate its scientific meaning to human actions.[72] Greek-American electrical engineer, physicist, and information theorist Panos Ligomenides, who reviewed Keranis' work, states that it captured his attention and increased his interest in the subject, particularly given the fact that, according to Ligomenides, 'the scientific and intellectual community has yet to embark on a thorough discussion of the laws of nature in relation to human existence and society.'

In the opening section of his work, one that Ligomenides cites as good, Keranis' outlines the difficulty in attempting to carry over only the second law, to the neglect of the other laws of thermodynamics, into the realm of human life, when he says 'social phenomena such as wars, financial crashes, traffic congestion or other similar manifestations of social disorder are taken as social expressions of the entropy law.' And that, in excellent form, he continues 'we can easily agree that such phenomena are indeed a kind of *dis-order*, when seen in the light of our life experiences and our legitimate desire to have a peaceful and quiet social life. But how relevant is this judgment to a proper reading of these phenomena that employs a natural law framework? More careful investigation will reveal that such phenomena are connected to the overall organization of the system's structures which results in the production of more and more work W in an environment of ever-increasing entropy S.'[72] Here, Keranis outlines the view that the second law regulates only one facet of human life, that of disorder and useful energy degradation.

The logic of Keranis' essay, according to Ligomenides, is based on 'the simplest consequence of the second law of thermodynamics: part of the energy available to produce any given amount of work is spontaneously downgraded and is wasted in the form of non-retrievable thermal energy; this is what is known as a non-reversible process.' This physics model, according to which the second law thermodynamics imposes limitations to any natural system's ability to convert all of its available energy into work, was Keranis' starting point.

In his essay, Keranis assumes that the earth is a closed thermodynamic system, and on this view then employs the Gibbs function [4.9] in order to derive the basic relationship between the energy capable of producing work and the energy lost as a consequence of the second law, also known as the 'law of entropy'. He points out that in any social system one observes processes that tend to release ever-increasing amounts of energy but, at the same time, one also observes processes which by their nature either do not contribute to or tend to control and or limit those of the first type.[72]

In sum, Keranis argues that the relationship between value flows and energy flows can be quantified by resorting to an analysis of the relationship between economic growth (energy flow) and social welfare (value flow) and that states of equilibrium, i.e. 'dynamic equilibrium', in society can be modeled using the Gibbs function in order to quantify the relationship between economic growth and social welfare posited by the Zolotas' function. All-in-all, this is a good application of basic thermodynamics theory in modeling the process of human life.

At the heart of every social system, however, is romantic life. The desire to pair to someone in such a manner to yield life-long happiness is a great objective. Thus, any viable social theory must be able to directly connect social system activity to romantic activity. In recent years, stemming from 1995 *Match.com* pair matching site, online couple matching sites have been making progress along these lines.

Online matching

Online matching is certainly one of the waves of the future. In time, video, audio, and speed-linking internet and web connections will be so commonplace, that its use will overtake that of in-person interaction. One recent study found that over the last ten years an estimated 3 million U.S. Internet users have clicked their way to love.[73] Three out of four internet users, for example, who are single and looking for a romantic partner have done at least one dating-related activity online: ranging from using dating websites, to searching for information about prospective dates, to flirting via email and instant messaging, to browsing for information about the local singles scene.[74] Likewise, 11% of all internet users and 37% of those who are single and looking say they have gone to dating websites.

Statistically, in the U.S. fully 43% of adults, i.e. 87 million people, say they are single and subsequently in the potential dating market. In more detail, the following table shows the bonding status for American adults, which accounts for 133 million people of the total U.S. population (288 million in 2005):[75]

Marital status	All Americans	Men	Women
Married	53%	56%	50%
Living as married	3	2	4
Never been married	21	25	18
Divorced	11	11	11
Widowed	9	3	14
Separated	2	2	3
Don't know / refuse to answer	1	1	1

In sum, each year 32 million American adults, i.e. 37% of 87 million, will consult a dating website. Of this group, millions will find dates through online match-making services.[76] The current model, however, 'is artificial and static, and far removed

from everyday social interaction,' says Jeana Frost, who along with Michael Norton and Dan Ariely took an academic look at online dating and how it can be improved. They describe their results in a recent Harvard Business School working paper, 'Improving Online Dating with Virtual Dates.' Frost, now at Boston University, wrote her PhD dissertation at MIT's Media Lab on the topic, discussing the broader issues of impression formation, navigating options, managing expectations, and informing decisions in mediated environments.[76]

Being fascinated with the psychological underpinnings of online interactions, Frost and Norton recently have begun to explore the social implications of people seeking relationships online and the possibility for technology to influence the initial tone and trajectory of relationships. One of their findings is that in the near future to help alleviate the static nature and time consumption associated with pair matching online, *virtual dating technology* will be needed. The basic concept behind it would be to create virtual spaces for easy, natural interactions with others. Potential daters would go on 'virtual dates' where desiring pairs would meet via an online icebreaker that allows feedback and interaction in real time using colors, words, and images.

With this tool, pairs could discern information such as: is my date responsive or funny? Are they on time? How do they dress? How do they unconsciously react to my questions? How does it feel to sit virtually across from them? What mannerisms does he or she have? These real-time interactions would allow people to converse, chat, and gesture naturally thus better mimicking an offline experience.

In current use, however, people spend 'hours and hours and hours a week online to generate one cup of coffee with one person', says Norton. Moreover, users often find that the person they meet for the first time was not what they had expected. 'By starting online, some people had experiences they wouldn't have had if they had been able to see up front what someone was like,' Norton says. His idea is to explore newer was to improve the experience online and help people filter more effectively.

As to the stability related to pairs made online, although there's no formal data, some claim that 'line parings' are more stable, others claim that internet marriages are no different than chapel marriage, yet others state that divorce rates are higher for those who meet online. There are certainly many factors that go into a thorough and detailed analysis of online marriage, one being that the average internet dater may be more of the adventurous type than as compared to non-internet daters. Those types of people who are explorers, for instance, tend to have higher levels of dopamine; as such, reaction rates for the more adventurous online explorer-types, and correlative debonding rates, related to marriages made this in this group may reflect this fact.[77]

To cite one perspective, lawyers in recent years have been seeing more internet-based divorce clients showing up on their doorsteps. New Jersey divorce attorney Eric Spevak, for example, says online-dating-related splits started picking up at his practice about five years ago. Spevak estimates that on average, one out of four or five of his firm's divorce cases stem from online dating and, as he says, 'I think it's a

trend that will continue'. Neutrally, online dating expert James Houran says there's no statistical research that suggests the success rate for online marriages is any different from that of conventional matchmaking.[73]

In short, over the last dozen or so years online matching sites have been playing internet cupid in efforts to help people match up together, supposedly, better than one can do on their own. The majority of current matching sites use questionnaires and computer algorithms to line up potential reactants. The following list shows the predominate pair-matching sites on the internet, ordered via *Alexa* traffic rankings (the numbers in quotes).[78]

-- Online Pair Matching Sites –

- *match.com* (142) – Phil McGraw's pair matching site started in '95 (the world's first).
- *eharmony.com* (951) – Neil Clark Warren's compatibility-based matching site.
- *true.com* (1,406) – offers scientific compatibility testing.
- *perfectmatch.com* (7,089) – Pepper Schwartz's lifestyle/personality matching site.
- *lavalife.com* (3,482) – dating service offering free matchmaking personal ads.
- ***chemistry.com*** (8,484) – Helen Fisher's chemistry-based matching site.
- *cupid.com* (12,519) – personal ads and online chatting and meeting.
- *udate.com* (20,069) – offers the very latest and most comprehensive matchmaking facilities.
- *gothicmatch.com* (58,893) – where gothic friends and singles feel at home.
- *theatlasphere.com* (81,919) – a place where admirers of Ayn Rand's novels can meet.
- *lovelee.com* (110,434) – a French pair-matching site for lovely people.
- *mary.com* (111,323) – matches with efforts to prevent divorce.
- *equestriancupid.com* (123,616) – matches friends and singles who are horse lovers.
- ***echemistry.com*** (352,726) – matches people, supposedly, using the scientific method.
- *cowboycowgirl.com* (401,295) – ads for people who share the country way of life.
- *philanderers.com* (435,845) – matchings for people seeking an extramarital affair.
- *golfmates.com* (531,441) – designed specifically for the golfing community.
- *biolovematch.com* (791,452) – matches people based on biorhythms.
- *debrawinkler.com* (1,557,358) – high-end $10,000 per match site.
- *goodgenes.com* (1,566,075) – matches ivy leaguers and well-educated graduates.
- *positivelove.com* (2,396,487) – matching so that STDs don't control one's life.
- *maydecember.net* (3,340,619) – ads for people interested in age-gap relationships.
- *asexualpals.com* (5,463,335) – matchings for asexuals.
- *singlefirefighters.com* (5,799,882) – a place to meet single firefighters.
- *liberalhearts.com* (5,847,470) – matches democrats, greens, and animal lovers.
- *millionarematch.com* (6,887,197) – matches millionaires.
- *riders2love.com* (N/A) – brings bikers together… for a ride of a lifetime.
- *conservativehearts.com* (N/A) – matches sweethearts not bleeding hearts.
- *singleswithscruples.com* (N/A) – matches based on integrity and good character.

These pair matching sites, from a high-energy particle physics perspective, are akin to human particle accelerators, functioning as high-speed catalytic reactors, resulting to fuel human chemical reactions at an accelerated rate. These sites are certainly an interesting and new way do to things, as compared to the traditional ways, such as through blind dates, meeting people at parties, clubbing, dating people from school,

work, or the local groups, meeting someone through the classifieds, speed-dating, dating services, arranged marriages, accidental encounters, meeting someone at a social dance or a festival, etc.[79] In other words, *line-dating* is another basic tool in the modern person's dating toolbox.

There are several pros and cons related to the use of pair matching websites. The main benefit is that it increases the number of potentials that one can meet via expansions of a person's set of interaction orbitals. Online one can easily meet someone from across the world or in the next town, whereas in daily life orbitals are relatively restricted to certain areas and people. One of the inherent issues with the use of matching sites is that online pair matching will always fail to incorporate various aspects of natural chemical reactions, such as real-time neuro-processing, exchange and feedback, e.g. via scent, or principles, such as the effects of collision theory. In natural substrate reactions, to go through one example, a certain amount of pre-conceived collisional energy will go into the reaction and be used to surmount the activation energy barrier; moreover, this natural energy will go into the efforts associated with the adjustment and breaking of old bonds and the forming new ones.

In this sense, chemical matches made through pair-matching sites will always be 'artificial' to a certain extent, being that it is impossible for a computer algorithm to exactly match or to emulate the natural collisional energy due to happenstance and circumstance. If two people, for example, have the natural predisposition to be lifeguards for the summer at the same local beach, the natural bound energy that each would have built up prior to this reaction path would function as a natural fuel in the course of their potential love reaction that could occur between these two human molecules. This natural energy would be used as they interact and mutually change each other over the course the summer, an energy that cannot be emulated by an algorithm or in a chat room. In an opposite sense, however, in the future it may be possible, through the use of human molecular satellite tracking technologies, to mathematically capture various aspects of collision theory and as such be used to facilitate reactions made in the net age.

Another main downfall of current matching sites is, knowing inherently that the processes of interpersonal love and hate are components of basic chemical reactions, that none of the current sites are matching from a *human chemistry* point of view, even though many lay-claim (such as the two sites shown bolded) to have found the secrets of the chemistry of love? The new 2006 pair matching site *Chemistry.com*, euphemistically claims, for example, that they will 'bring you the chemistry to make it happen'. Likewise the new 2006 pair matching site *eChemistry.com* claims that by using the new 'science of attraction' they have 'taken the mystery out of romantic chemistry using nine years of research to match single users using personality patterns scientifically isolated in old high-chemistry couples.'[80]

Moreover, none of the above listed current pair matching sites are run by actual chemists, physical chemists, quantum chemists, biochemists, chemical engineers, or

chemical thermodynamicists, etc., as would be the case if the reactions between human molecules were to be matched correctly. There is one exception. Namely, *eChemistry.com* was actually started by someone with a chemical background. This particular match-site was started by Glenn Gasner, an American chemical engineer. He is the one 'chemist', i.e. chemical engineer, who seems to have an interest in pair matching and we specifically commend him for this effort.

How he was led into developing his matching site, however, did not involve a chemistry textbook. In particular, when he was 24, he really wanted to get married. To complete this objective, he decided that by his 25th birthday, he wanted to be *rejected* 100 times when asking for dates. In doing this, he figured that he would learn a lot about pair matching and that he could potentially meet Ms Right.[81]

It was quite an adventure, he asked out, as he says, virtually every girl he came across. He asked the girl handing out pamphlets in the doorway where he worked, he asked a girl seated at the next table at a restaurant, he asked every girl who came near him. One lesson that he learned from this experiment, in his own words, 'is that anyone can get good at *anything* if they do it 100 times.' By his 25th birthday, however, he had devised a new plan. Namely, he decided that, on average, about 1 in 10 females would be physically attractive enough for him to marry and that they would feel the same about him in the reverse sense. He also assumed that a 1 to 10 ratio would exist in terms of personality compatibilities. With this logic, he calculated that 1 in 1,000 females would be a marriage-level match for him, i.e. that they were both physically attracted to each other and that they got along.[82]

Using this new ratio, and knowing for sure that he wanted to be married by age 35, he the calculated that he would have to date 100 girls each year for ten years, i.e. two each week, to be sure to find the right one. This is certainly very ball-park math and of course doing experiments on oneself will always have the effect of biasing the results, but, nevertheless, the story is kind of interesting.

Along the way, he had developed an interest in personality typing, i.e. keeping track of personality traits of people. When he dated, for example, he would ask a lot of questions and keep track of how much attraction there was, mutually. In this manner, after doing some reading, research, and pattern tracking, he noted that each personality system has its own basic predictions of who should be attracted to whom. In addition, he began typing his friends, married friends, and associates to see if he could gauge patterns and make predictions.

From his dating experiences and data collections he then had a long list of couples and a long list of personality variables and miniscule traits. In addition, at the time he was working as a chemical engineer, where his job description was, in his own words, 'to deconvolute complex chemical reactions, using statistics and complex math to determine the relative importance and interaction of each chemical that went into a reaction to explain the real life outcome, and then to use that knowledge to predict the ratios which would produce the optimum real world super-

compound.' With this rather verbose job description, dating experience background, and trait data set collection, he says that he 'found the patterns and ratios which cause romantic chemistry.'[81]

Although he keeps his matching algorithms a secret, as most matching sites do, it is likely, as based on his 'how this site came to be' overview and the descriptions presented on *eChemistry.com* that his website is no different, in theoretical structure, than any other matching site, in that its algorithms are not based on the science of chemistry.[83] In short, what he seems to do, as many sites do, is to sell, promote, popularize the catchy word 'chemistry', in a romantic sense, without backing up basic claims with sound theory, such as is found in a chemistry textbook.

On his site's home page, for example, one can watch a flashy video overview, where it is claimed that his site has 'taken the mystery out of romantic chemistry' by studying '2,400 years worth of research by Galileo, Aristotle, Hippocrates, Hathaway and McKinley, Costa and McCrae, Jung and Myers Briggs, Salovey and Mayer, and Chapmen' to 'figure out the traits that cause chemistry' using the latest 'cutting edge romantic chemistry research'.[84] Moreover, one can view 'the careers and hobbies which people of your type *gravitate* toward'. Here, as we see, he is obviously mistaken in his basic pair matching theories when he uses the mis-applied colloquial word 'gravitate'; the correct word is *electromagnetate*. In addition, the specific traits he uses to match people 'chemically' are 'personality, age, religion, smoking, children, pets, location, and politics'.[85]

This is all good, except his site video presentation used to back up his chemistry claims is nothing more than a lot of fluffy pop advertising, with no realistic or substantial meat; basically used to catch new paying subscribers, who will invariably be uneducated from a chemical point of view. The educated chemist will know, for example, that none of the people listed above are significant or even relevant in the development of the related fields of chemistry, biochemistry, neurochemistry, supramolecular chemistry, quantum chemistry, thermochemistry, chemical thermodynamics, or human chemistry.

Hippocrates (460BC) was a physician; Aristotle (384BC) was a philosopher; Galileo Galilei (1564) was an astronomer; Jung (1875) was a psychiatrist; the *Myers-Briggs Type Indicator* is a personality test designed to assist a person in identifying some significant personal preferences, developed by Katharine Cook Briggs and her daughter Isabel Briggs Myers during World War II (1939-1945), and its criteria follow from Carl Jung's theories in his work 'Psychological Types'; Hathaway and McKinley developed the *Minnesota Multiphasic Personality Inventory* (1940); Costa and McCrae developed the newer *Revised Neuroticism-Extroversion-Openness (NEO) Personality Inventory* (1970s); which is a basic psychological personality assessment inventory, i.e. a 240-questionaire measurement of the *Five Factor Model*: extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience; Salovey and Mayer are notable for their coining of the term *emotional*

intelligence (1990), which they define as 'a from of social intelligence that involves the ability to monitor ones own and other feelings and emotions, to discriminate among them, and to use this information to guide ones thinking and action'; and Chapman is the author of popular 1992 book *The Five Love Languages: How to Express Heartfelt Commitment to Your Mate*, which posits that every person feels most loved when love is expressed through one of five modes: words of affirmation, quality time, gifts, acts of service, or physical touch.[86]

This research program is the scientific foundation and theoretical structure of Gasner's 'eChemistry' or *romantic chemistry* as he calls it. The good point about his website is that he says he uses the scientific method, as pioneered Aristotle and Galileo.[87] The obvious inconsistency in his various claims, e.g. that he has 'taken the mystery out of romantic chemistry', is that none of the people he cites as references are chemists or have anything to do with the basic science of chemistry? Most people cited are psychologists? In short, Gasner is using false advertising, as many do, by claiming that his website is matching according to the science of chemistry.

This modern situation, in which charlatan webmasters sell digital love potions, to unsuspecting users, is similar to the 17th century days when optimistic alchemists would claim to have found the Philosopher's stone by which they could make gold or potions by which users could fall in love.[88] In 1661, Anglo-Irish chemist Robert Boyle, one of the founders of modern chemistry, for example, had to point out to all the alchemists that what they were doing, with all their false claims, was detrimental to the betterment of the science of chemistry:[89]

> "If men would more carefully distinguish those things that they know from those that they ignore or do but think, and then explicate clearly the things they conceive they understand, acknowledge ingenuously what it is they ignore, and profess so candidly their doubts, that the industry of intelligent persons might be set on work to make further enquiries, and the easiness of less discerning men might not be imposed on."

In apology for being so sharply abrupt, Boyle continues 'I perceive that [various] of my friends have thought it very strange to hear me speak so irresolvedly, as I have been wont to do, concerning those things which some take to be the elements, and others to be the principles of all mixt bodies.' Here, Boyle is criticizing earlier research founded on the belief that salt, mercury, and sulphur were the 'true principles of things'.[90] Likewise, here we are criticizing earlier research founded on the belief that basic psychological personality assessments are what constitute the true 'mystery of romantic chemistry'.

Many noted matchmakers, however, fall victim these types of false conclusions in regards to what exactly constitutes 'chemistry' between people. Many naively believe that 'chemistry' is some type of magical romantic state that can be found between people in the coveted love-bird stage. This is an immature point of view. Everything, in fact, is chemistry. It's not simply a mixture of heart putters, dilated pupils, butterflies, endorphins, pheromones, phenethylamine, and heightened states of pleasure-center neurological activity; the correct view is that everything in life is chemistry. The entire start to finish process of any relationship, or a person's entire life for that matter, good or bad, is chemistry.

Yet, many remain in the dark about this obvious fact. American psychologist Neil Warren, the founder of *eHarmony.com*, for example, states that in his studies of over 5,000 married couples, where his team of researchers studied the differences between both happy and unhappy married couples and found combinations of twenty-nine key dimensions that predict great relationships including: adaptability, curiosity, intellect, values, beliefs, spirituality, feelings about children, and relationship skills, such as conflict resolution, that he basically finds that 'chemistry is not enough … almost all marriages start out with good chemistry, yet three out of four couples end up unhappy or divorced.'[91]

Other researchers include: Helen Fisher, an anthropologist, who is the principle researcher behind *Chemistry.com*; Pepper Schwartz, a sociologist, who is the principle researcher behind *PerfectMatch.com*; and Phil McGraw, i.e. 'Dr. Phil', the psychologist associated with Oprah's day-time talk show, is the principle researcher behind *Match.com*.[92] Some of these researchers, which are basically the ones who write the online interview questions, are so uneducated in their knowledge of basic chemistry, that they end up making ridiculous statements about what they perceive as 'chemistry'. In a 2006 interview of Helen Fisher, for example, when asked if her site can actually predict chemistry between people, she replied 'there will always be magic to love, [but] no one can predict exactly who becomes electrified by whom.'[93] This is clearly wrong, chemists can predict, with ease, what molecules will react or become 'electrified by whom'. This is done with what are called thermodynamic tables.[94] Moreover, magic is not a word used in chemistry. *Magic*, including the arts of prestidigitation and conjuring, is the art of entertaining an audience by performing illusions that baffle and amaze, often by giving the false impression that something impossible has been achieved. In all cases, illusions of magic are created entirely by natural means. Similarly, in a 2007 interview of Pat Dimes, founder of *Mary.com*, he stated that 'I'm not a big believer in finding chemistry online. Meet people offline, and then come online.' Yet he incorporates online tests at his website that can supposedly match people 'off the charts' when it comes to chemistry.[73]

Our point here, to note, is not to site-bash online relationship researchers, but rather to point out that all pair matching sites, in the future, will need to have huge overhauls if they are to be compatible with the modern sciences of human chemistry

and human thermodynamics. Helen Fisher, despite her lack of a degree in chemistry, has been invariably the world's most referenced researcher and promoter of the topic of love in relation to chemistry and in this sense is a sort of pioneer in the science of human chemistry. Moreover, her site *Chemistry.com* does seems to correctly use various facets of chemical theory to match people.

Through her numerous publications, such as her 2004 book *Why We Love – the Nature and Chemistry of Romantic Love*, for example, we know facts such as that when testosterone washes over the brain in the womb, it builds aspects of personality and lengthens the fourth finger.[93] Thus, online, a good question they ask a person is to measure the fingers on their right hand, thus allowing a computer algorithm to obtain what is called a 'digit ratio', i.e. the length of one's second finger (pointing finger) as opposed to their fourth finger (ring finger). This ratio can indicate several aspects of personality, including the degree to which one is, by nature, assertive, verbal, musical, analytical and systematizing.

In addition, Fisher distinguishes between four personality types each of which she associates with a body chemical: *explorer* (dopamine), *negotiator* (estrogen), *director* (testosterone), and *builder* (serotonin). Specific personality traits, according to Fisher, correlate to increased hormonal activity in the brain. Increased dopamine levels, for example, are linked to risk taking, spontaneity and optimism, while high serotonin activity correlates to loyalty, conscientiousness and calmness. A high level of estrogen, in males or females, is associated with imagination, verbal ability and idealism; and testosterone relates to rationality, inventiveness and directness.[77]

Along these lines, at *Chemistry.com*, Fisher has designed an interactive online test to enable users to identify their own levels of each of these four body chemicals: two hormones (testosterone and estrogen) and two neurotransmitters (serotonin and dopamine). One question, for example, is to ask if a person has a tendency to count things around them, such as books, stairs, or flower petals. Counters tend to have higher levels of dopamine and can be categorized as the explorer type. In a similar manner, people who experience déjà vu frequently, according to Fisher, tend to have higher estrogen levels in the brain and can be categorized as negotiators.

Once a person's type is determined, biologically speaking, people with high levels of estrogen (negotiators) can be matched with those who have increased levels of testosterone (directors). In the same way, Fisher says, explorers with elevated dopamine activity are well-matched with builders who have increased serotonin activity. The two are balancing each other out, and the personalities not only fall in love, but stay in love, because they're enough different from each other to remain alluring and attractive, she says. This sort of chemistry is backed up by evolution, in which it is adaptive, according to Fisher, to find a partner who is not exactly like you so you can create more genetic variety in your young. We're drawn to these other personality types for good Darwinian reasons.[77]

Fisher, in this sense, is using scientific theory based on findings in biochemistry and neurochemistry to build a good chemical matching algorithm. Moreover, she is open about her findings, which benefits everyone in the scientific community. These types of theories and applications will no doubt find a continued and successful application in the years to come. Others would be wise to emulate her style.

In human chemical terms, however, the only true way to find the absolute most reactive pure match is by constructing a *free energy table* of the world's population. This would be analogous to Goethe's *affinity table* of 1809. Moreover, through the use of chemical kinetics, one can also pre-determine how fast reactions will go, when certain love reactions will end, which pairs will debond, etc.

In the future, science will be able to tell a young child, for example, that he or she, based on their human molecular data sets, will be predisposed with the tendency to have three to five main love reactions in the course of their life or conversely that he or she will be predisposed with the tendency towards having one main love reaction lasting through their life course. These reaction predictions, of course, will depend on the human molecules involved.

Some may actually like this point of view. For some, it will actually be morally correct to have multiple reactions as contrasted with the mythical or hypothetical one ideal reaction that everyone is supposed to follow. In other word, pairs match such that they fall in love with each other with a passion and stay bonded, equilibriating or thermalizing along the way, until they burn their potentials. This is the way all chemical reactions work; it should be no surprise to find this same basic pattern to exist in human molecular reaction life. Hence, knowing that all chemical reactions have different reaction rates, it would be good to be proactive in this line of research.

A true rigorous science of *human chemistry*, in spite of the fact that we have outlined the basics of this science here, however, will not likely come into it own at least for another 200 to 300 years or so. Subsequently, a good rule of thumb is that if someone claims to have figured out the chemistry of love and it's not past the third millennium then they are most-likely pulling your strings.

Human affinity (Gibbs free energy) tables

Invariably, the starting point for gauging a potential reaction between two people is the measure of mutual affinity between the pair. Moreover, chemical affinity and human affinity, as Goethe has shown, are one and the same. In 1718, to review, Geoffroy published his famous affinity table able to successfully predict reactions between selective chemical substances. The tables, however, were crude. Geoffroy left open the possibility that his affinity table could be refined with further accumulation of facts and that some of his analyses were not 'perfectly exact and precise', but that they remained within a tolerable limit of precision. In other words, the tables were accurate only to within the level of available techniques of chemical

analysis. Likewise, according to French scientist Bernard Fontenelle, 'the more chemistry becomes perfect, the more the table of M. Geoffroy will become perfect as well, either by a great number of substances that it contains or by the arrangement and the exactitude of rapports.' Fontenelle's vision, in current years, is such that we now have affinity tables for, essentially, any reaction between chemical species having a molecular structure of approximately five elements or less.

In 1882, Helmholtz proved that the thermodynamic quantity called free energy is the true measure of intermolecular chemical affinities. In this direction, the first free energy tables were constructed by German chemist Fritz Haber in his 1905 book *Thermodynamics of Technical Gas Phase Reactions*. In this book, he was the first to systematically study all of the thermodynamic data necessary for the calculation of free energy changes in chemical reactions. Later, in 1957, the first thermodynamic table of biochemical species was published by K. Burton, which contained about 100 species. This table was able to successfully predict biochemical reactions between selective biochemical species. The 2003 textbook *Thermodynamics of Biochemical Reactions* by American biophysical chemist Robert Alberty are loaded with modern *Mathematica* programs set to facilitate thousands of various potential reactions.

The direct extrapolation in human chemistry is clear. In time, affinity or free energy tables will be formulated for human molecules. In other words, in the future instead of going to the local bar or dance club to find a passionate match, a person will be able to consult human free energy tables, likely listed online, and thus be able to pick out the one person in the world with which he or she will have the greatest interpersonal chemical affinity and reaction potential.

In the coming millennium, we propose that someone will construct a digitized, complete, and exacting world encompassing, human affinity table, updated on the microsecond, able to categorize the rapports of billions of human molecules. That is, it will be possible for a willing and interested person to consult human affinity tables, or technically 'human thermodynamic tables', to see the energetic rankings of those human molecules with which he or she will be most apt to bond to or react with, as well as those human molecules for which chemical reactions would be extremely disfavored. The time, frustration, and mental repercussions of having gone through malformed, non-favored, or troubled reactions will be spared.

Once the inquisitive user puts themselves in the physical proximity of the other, the reaction would be irresistible. For the most intimate of personal reactions, one will be able to select the most chemically and thermodynamically matched person on the face of the earth to react with, such that no other human molecule would have the power or affinity to displace the one most potent, at least within the equilibrium confines the reaction window.

In modern terms, free energy tables are also called *thermodynamic databases*, which contain information about thermodynamic properties for chemical species and substances, the most important being enthalpy, entropy, and Gibbs free energy.[94]

Numerical values of these thermodynamic properties are collected as tables or are calculated from thermodynamic datafiles. Thermodynamic data is usually presented as a table or chart of function values for one mole of a substance. A *thermodynamic datafile* is a set of equation parameters from which the numerical data values can be calculated. Tables and datafiles are usually presented at a standard pressure of 1 bar or 1 atm, but in the case of steam and other industrially-important gases, pressure may be included as a variable. An example of a basic free energy table, for a few simple chemical species, as found in Raymond Chang's 1998, 6th edition *Chemistry* textbook, is shown below:

Species	Formula	ΔH_f°(kJ/mol)	ΔG_f°(kJ/mol)	S°(J/K·mol)
Acetic acid(l)	CH_3COOH	-484.2	-389.45	159.83
Acetaldehyde(g)	CH_3CHO	-166.35	-139.08	264.2
Acetone(l)	CH_3COCH_3	-246.8	-153.55	198.74
Acetylene(g)	C_2H_2	226.6	209.2	200.8
Benzene(l)	C_6H_6	49.04	124.5	172.8
Carbon dioxide(g)	CO_2	-393.5	-394.4	213.6
Ethanol(l)	C_2H_5OH	-276.98	-174.18	161.04
Ethane(g)	C_2H_6	-84.7	-32.89	229.49
Ethylene(g)	C_2H_4	52.3	68.1	219.45
Formic acid(l)	HCOOH	-409.2	-346.0	128.95
Glucose(s)	$C_6H_{12}O_6$	-1274.5	-910.56	212.1
Methane(g)	CH_4	-74.85	-50.8	186.19
Methanol(l)	CH_3OH	-238.7	-166.3	126.78
Oxygen(g)	O_2	0	0	51.05
Sucrose(s)	$C_{12}H_{22}O_{11}$	-2221.7	-1544.3	360.24
Water(l)	H_2O	-285.8	-237.2	69.9

In this table, the standard free energy of reaction ΔG°_{rxn} is the free energy change for a reaction when it occurs under standard-state conditions, when reactants in their standard states are converted to products in their standard states. Hence, to quickly calculate, for example, if methane CH_4 is energetically favored to react with oxygen O_2, we first use the following basic relation:[95]

$$\Delta G^\circ_{rxn} = \sum n\Delta G_f^\circ(\text{products}) - \sum m\Delta G_f^\circ(\text{reactants}) \qquad [11.16]$$

where m and n are stoichiometric coefficients. Thus, if we use this expression in coordination with the stoichiometrically balanced reaction for these two species:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \qquad [11.17]$$

we can calculate the free energy change for the reaction. Specifically, if we plug in the Gibbs free energy of formation for each species in reaction [11.16] into equation [11.16], we have:

$$\Delta G°_{rxn} = [\Delta G_f°(CO_2) + 2\Delta G_f°(H_2O)] - [\Delta G_f°(CH_4) + 2\Delta G_f°(O_2)]$$

Then, with the appropriate values from the above table we write:

$$\Delta G°_{rxn} = [(-394.4) + 2(-237.2)] - [(-50.8) + 2(0)] = -818.0 \text{ kJ}$$

Thus, according to the reaction rules outlined in chapter four, namely that:

Value	Result
$\Delta G < 0$	Favored or spontaneous reaction
$\Delta G = 0$	Reversible or equilibrium reaction
$\Delta G > 0$	Dis-favored or non-spontaneous reaction

we see that the potential bonding reaction between the simple methane molecule and the oxygen molecule will be favored, i.e. a spontaneous reaction. We could then pair up other potential reactants with methane CH_4 and calculate the free energy changes for those potential reactions. If we were to do this, we would find that methane is extremely reactive with oxidizers, halogens, and some halogen-containing compounds. If all of these reactions were to be tabulated, we would invariably find that the one reaction pairing that has the largest negative free energy change would be the most-spontaneous and thus favored more so than any other pairing.

The basic chemical reaction rule is that the reaction with the most negative Gibbs free energy change ΔG will the most favored and thus by [11.13] will be a pair in possession of great amount of natural and mutual affinity. In this manner, as Helmholtz showed in 1882, such a reaction will yield the maximum amount of work-output more so than any other potential pairing, if the reaction were to be carried out reversibly, i.e. as an ideal reaction. In colloquial terms, instead of having to work on your relationship, your relationship will work.

These same basic principles apply for all human chemical reactions. In other words, through Gibbs free energy calculations of potential human reaction pairings one can determine who in a person's small-world system, i.e. school, job, town, region, etc., would yield the most negative free energy change and thus determine which relationships would work the best.[96]

In the following chapters, we will continue to build on this affinity / free energy outline by first stepping through the early development of bonding theory in the 20th century, stemming from such figureheads as Sigmund Freud, Konrad Lorenz, Anna

Freud, and John Bowlby, and then into a modern-day description of human chemical bonding, inclusive of affinity, free energy, quantum mechanics, and the quantum electromagnetic force, and the various bonding terminologies used presently.

12 – Bond History and Neurochemistry:

"Love is indeed the *glue* of human existence."

Anthony Walsh, American sociologist[11]

The conception of the existence of ties, bonds, or attachments, between humans has a long history, beginning with early third millennium BC thoughts on bonds or nets of love to the 21st century models of limbic bonding. The central turning point in history of human bonding theories was the development of psychodynamics by Sigmund Freud, from 1874 to 1923, and the later psychological bonding ideas of his daughter Anna Freud who began to apply the principles of psychodynamics to parent-infant attachment.

In psychology, *psychodynamics* or 'dynamic psychology' is the study of the interrelationship of various parts of the mind, personality, or psyche as they relate to mental, emotional, or motivational forces especially at the unconscious level.[1] The original theory of psychodynamics was developed by Sigmund Freud who, in the late 1870s, began to apply the principles of thermodynamics, predominantly those of German physician and physicist Hermann von Helmholtz, to psychology. Hence, according to this theory, psychological processes are flows of psychological energy in a complex brain. Freud founded 'psycho-dynamics' then on the concept of mental or psychological energy, which he called libido.[2] Based on 'thermo-dynamics' of closed systems, Freud proposed that psychological energy was constant (hence, emotional changes consisted only in displacements) and that it tended to rest (point attractor) through discharge (catharsis).[3]

In mate selection psychology, psychodynamics is defined as the study of the forces, motives, and energy generated by the deepest of human needs.[4] In general, psychodynamics studies the transformations and exchanges of *psychological energy* within the personality.[5] A focus in psychodynamics is the connection between the energetics of emotional states in the id, ego, and superego, a theory developed by Freud in 1923, as they relate to early childhood developments and processes. At the heart of psychological processes, according to Freud, is the *ego*, which he sees battling with three forces: the id, the super-ego, and the outside world.[6] Hence, the basic psychodynamic model focuses on the dynamic interactions between the id, ego, and superego.[7] Psychodynamics, subsequently, attempts to explain or interpret behavior or mental states in terms of innate emotional forces or processes.

In 1910, at the age of fifteen, Freud's daughter Anna began to study her father's theories especially that of the ego and in the 1940s began to apply her conceptions of psychodynamics to parent-infant attachment.[8] These conceptions in turn, directly

influenced two co-workers, named James Robertson and John Bowlby, at the Tavistock Clinic in London who in 1948 began to develop a foundation of a dynamic psychological theory of human bonding and attachment. Prior to this, however, are the earlier views of the force of love functioning as the bond along with other views.

Early views

In the ancient third millennium BC Chinese book *I Ching* or 'Book of Changes', one of the classics of Confucianism, we find the hypothesis that 'a close *bond* is possible only between two persons; a group of three engenders jealously.' In modern terms, this is often paraphrased as 'two's company, but three's a crowd'.[9] In the fourth century, Chinese sage Lao Tzu, in his famous *Tao Te Ching*, stated that 'when soul and body are in the *bond* of love, they can be kept together.'[10] In the 1300 BC Egyptian poem *Pleasant Songs of the Sweetheart Who Meets You in the Fields*, a women uses metaphors to speak about chemical bonds, when thinking about her loved one, namely 'the nets of your love have trapped me'.

In about 450 BC, Greek pre-Platonic philosopher Empedocles argued that love is the great unifying life-force of nature functioning to *bond* all things, both animate and inanimate.[11] In the 4th century BC, similarly, the Greek philosopher Plato argued that love, in a way, directs the bonds of human society. In his *Symposium*, Eryximachus, one of the narrators in the dialog, states that love goes far beyond simple attraction to human beauty: It occurs all throughout the animal and plant kingdoms, as well as all throughout the universe. Love, according to Plato, directs everything that occurs, in the realm of the gods as well as that of humans.[12]

Eryximachus reasons that when various opposing elements such as wet and dry are 'animated by the proper species of love, they are in harmony with one another; but when the sort of love that is crude and impulsive controls the seasons, it brings death and destruction.'[13] As it is love that guides the relations between these sets of opposites throughout existence, according to Eryximachus, in every case it is the higher form of love that brings harmony and cleaves toward the good, while the impulsive vulgar love creates disharmony. He concludes that the highest form of love is the greatest; when it 'is directed, in temperance and justice, towards the good, whether in heaven or on earth: happiness and good fortune, the *bonds* of human society, concord with the gods above-all these are among his gifts.'[14]

In the 12th century, French abbot Saint Bernard of Clairvaux spoke of the '*glue* of love'. In the 1590s, English writer William Shakespeare wrote 154 poems in sonnet form in which he used phrases such as 'seal'd false *bonds* of love' and 'to seal love's *bonds* new made', etc. In the 1660s, the Dutch philosopher Spinoza writes, in his *Ethics of Human Bondage or the Strength of the Emotions*, that the term 'bondage' relates to the human infirmity in moderating and checking the emotions. That is, according to Spinoza 'when a man is prey to his emotions, he is

not his own master, but lies at the mercy of fortune.' He also intelligently notes that bondage operates such that one is often compelled, while seeking that which is for the better, to follow that which is for the worse. This is take on the theory of predisposed movement.[15]

In 1809, Johann von Goethe in his classic novella *Elective Affinities*, speaks of the 'marriage tie' and by analogy shows how strong marriage unions are similar in character to that by which the particles of quicksilver find a unity together though the process of chemical affinity. Goethe's novella, in its time, was regarded as treatise on the chemical origins of love. Humans in passionate relationships, according to Goethe, are analogous to reactive substances in a chemical equation and the bonds of those unions are directed by a 'chemical force' or affinity as outlined originally by Isaac Newton in his 1687 *Principia*.

In the remainder of the 19th century, others, similar to Goethe, began to theorize about the nature of love or drives in terms of physics. In 1819, German philosopher Arthur Schopenhauer viewed love and its direct and indirect affairs to be the central topic of life and addressed it and its related concepts, forthrightly. The obviousness of this central fact was famously outlined by Schopenhauer:

> "We should be surprised that a matter that generally plays such an important part in the life of man [love] has hitherto been almost entirely disregarded by philosophers, and lies before us as raw and untreated material."

He gave a name to a 'force' within man which he felt had invariably precedence over reason, namely *Will to Live* (Wille zum Leben), defined as an inherent drive within human beings, and indeed all creatures, to stay alive and to reproduce. In modern term, this drive or will to live, Schopenhauer refers to, is the thermodynamic drive of free energy, divided between the enthalpic drive and the entropic drive. Moreover, Schopenhauer refused to conceive of love as either trifling or accidental, but rather understood it to be an immensely powerful *force* lying unseen within man's psyche and dramatically shaping the world:

> "The ultimate aim of all love affairs ... is more important than all other aims in man's life; and therefore it is quite worthy of the profound seriousness with which everyone pursues it … what is decided by it is nothing less than the composition of the next generation."

In his central work, the 1819, 694-page, *The World as Will and Representation,* electricity and gravity are correctly described as the fundamental forces of a person's

will, a fact that will be addressed in the following chapter. These ideas foreshadowed and laid the groundwork for Darwin's theory of evolution and Freud's concepts of the libido and the unconscious mind.

In 1882, German economist Max Weber began theorizing about social elective affinities, where the human tie or bond is characterized by a dynamic force of affinity that mediates social change.[16] After 1897, however, with discovery of the *electron*, a negatively charged subatomic electrical particle that can be stripped from atoms to form cathode rays, a discovery made by British physicist Joseph Thomson, the use of the term 'bonding' in human relationships became more complicated. In 1916, American physical chemist Gilbert Lewis, in his famous article 'The Atom and the Molecule', introduced the theory that a chemical bond is a result of atoms sharing *pairs* of electrons. Specifically, 'in order to express the idea of chemical union I would suggest the use of a colon (A:B), or two dots arranged in some manner, to represent the two electrons which act as the connecting links between the two atoms.' In the years to follow, chemists would often use the phrase *electron-pair-bond* to define a chemical attachment. In 1929, in an article published by the *American Chemical Society*, for example, we find 'the electron-pair bond is two bonding electrons symmetrically related'.[17]

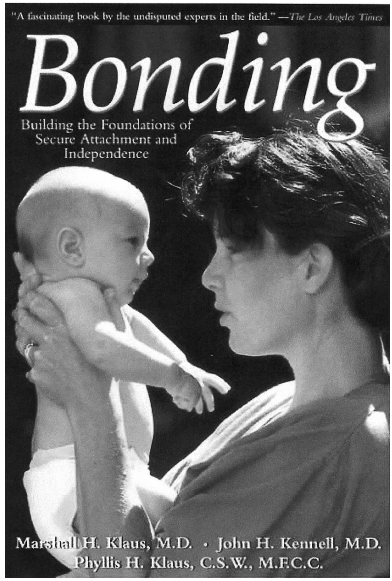
In analogy to this phrase, ornithologists, ethologists, and biologists soon began to use the term 'pair-bond' in relation to animal mating, particularly in bird mating behaviors. In a 1932 issue of the *Journal of Animal Ecology*, for example, we find 'Red-billed gulls which changed mates had significantly lower hatching (17.9%) and fledging (21.1%) success the previous season than did those birds which retained the *pair-bond*.'[18] By 1940, the term 'pair-bond' in ethology was common jargon.[19]

A second major event, aside from the discovery of the electron and the theory of the pair bond, to have an indirect influence on human bond theory development was World War II, a worldwide military conflict that lasted from 1939 to 1945. World War II was the amalgamation of two conflicts, one starting in Asia as the Second Sino-Japanese War and the other beginning in Europe with the Invasion of Poland.[20]

During the period, childcare in hospitals, especially in London, often took the brunt of the residual effects of the war. In a long-stay ward at Harefield Hospital in Middlesex, during this period, for instance, there were sixty beds for children with pulmonary tuberculosis, where the children were kept in glass-front cubicles.[21] Moreover, before the days of modern medicines, stays of three to four years were not uncommon and visiting hours were such that children under three were not allowed visits, but parents could see their children through partitions and children three years or older were allowed one-hour visits, twice weekly.[21]

This odd situation attracted the great child psychological minds of those as Anna Freud, Melanie Kline, James and Joyce Robertson, John Bowlby, Mary Ainsworth, Marshall Klaus, and John Kennell, an associative synergy that fortuitously resulted in the development and publication of a number of new bonding and attachment

theories, culminating with the 1976 book *Maternal-Infant Bonding* and a later third 1995 edition directly-titled *Bonding: Building the Foundations of Secure Attachment and Independence*, by Marshall Klaus, John Kennell, and Klaus' wife Phyllis, a social worker, with a fascinating cover (shown below):


"A fascinating book by the undisputed experts in the field." —The Los Angeles Times
Bonding
Building the Foundations of Secure Attachment and Independence
Marshall H. Klaus, M.D. • John H. Kennell, M.D.
Phyllis H. Klaus, C.S.W., M.F.C.C.

Klaus, Kennell, Klaus' *Parent-Infant Bonding* (1995)

What is fascinating about this excellent cover is the visual effect: namely that there exists some type of bond between the two individuals on the cover. So obvious is the bond between these two individuals that it goes without question. Yet, the term 'bonding' is a tool of the chemist? Why then has no chemist ever written an article or book on human chemical bonding? Therein lies the puzzling riddle: why do the psychologists write about bonding and not the chemists? Is it that the chemical bond is so very elusive and complicated that only the skilled psychologist understands its operation rather than the chemist?

In any event, owing to the popularity of this book, according to Merriam-Webster, in the years to follow the publication of the first edition, 1979, the term 'bonding' and its various theories began to be applied to personal relationships and particularly romantic love relationships. In 2005, for their significant bonding-theory work and outstanding lifetime accomplishments in fostering early parent-infant development, Marshall, John, and Phyllis received the *Arnold Lucius Gesell Prize* from the Theodor Hellbruegge Foundation in Munich, Germany, which was given to them at an international symposium 'Beginnings of Parent-Infant Bonding and Attachment: Pregnancy, Birth and the Role of Psychotherapy'.

All of this bonding theory synergy, originally, centered around the Tavistock Clinic, between 1938 and 1975, a noted mental health facility and outpatient clinic in London, outside of which stands a statue of Sigmund Freud.[22]

Tavistock Clinic bonding school

In 1938, the Freud family had to flee from Austria because of the Nazis' continuous harassment of Jews in Vienna. In addition, Freud's health was getting bad due to a severe jaw cancer infection. Resultantly, Anna Freud, the sixth and last child of Sigmund and Martha Freud, a noted child psychologist in her own right, organized the family's emigration to London. When Anna arrived in London, a conflict emerged between her and Austrian-born British child psychoanalyst Melanie Klein regarding developmental theories of children.[23]

The war, however, gave Anna opportunity to observe the impact of deprivation of parental care on children. As a result, she set up a center for young war victims, called *The Hampstead War Nursery*. Here the children got foster care although mothers were encouraged to visit as often as possible.

In 1941, psychiatric social worker James and his wife Joyce Robertson joined Anna in the *Hampstead Wartime Nurseries*. Joyce was a student caring for the infants who had lost family life due to the war. James began by organizing the maintenance and fire-watching but later became a respected social psychoanalyst, a tuition funded by Anna. Both James and Joyce benefited from child psychodynamic teachings given by Anna Freud.[23]

After the war, in 1948, James trained as a psychiatric social worker, and later Joyce (1965), joined burgeoning attachment theory pioneer John Bowlby at the Tavistock Clinic, to make observations on separated young children. As a convenient way to do so, he was sent to the short stay children's ward at the Central Middlesex Hospital in London. During these years, James conducted research on child-parent separation in local hospitals around London. In 1952, James made a short 80-minute now-classic film called *A Two-year-old goes to Hospital*, a record of a young child's stay in hospital.[24] It would allow the evidence to be examined and re-examined. He hoped it would pierce defenses that the spoken word could not. Over the years, he and Joyce made five such films. Joyce, after taking time out to raise their two daughters, joined the clinic in 1965. These films and notes on how children respond to a loss of their mother, later became the research foundation of Bowlby's famous 1969 three-volume *Attachment Theory* opus. In Bowlby's own words, in reference to Volume 1 of *Attachment and Loss*, 'the main data on which I have drawn are those of James Robertson'.[25]

In 1950, American early developmental psychologist Mary Ainsworth joined the research team at Tavistock Clinic investigating the effects of maternal separation on child development. Comparison of disrupted mother-child bonds to normal mother-child relationship showed that a child's lack of a mother figure leads to adverse development effects. Her work in early emotional attachment resulted in the 'Strange Situation' theory, in which children are put in strange situations to see and study their reactions, further developed the new science of attachment theory.[26]

In the 1970s, American pediatricians Marshall Klaus and John Kennell engaged in a number of thought-provoking discussions with James and Joyce Robertson and John Bowlby on the topic of the early attachment process in the development of the parent-child tie.[27] As a result of these exchanges and discussions, Klaus and Kennell was stimulated to write the influential 1976 book *Maternal-Infant Bonding*.

Unifying all this bonding theory were earlier debates about animal behavior, i.e. whether behavior is spontaneous, but independent of external stimulation, or whether it could be explained as a combination of reactions to the environment. In 1918, for instance, German-born American Jacques Loeb positioned his theory of *tropisms*, in which behavior and animal conduct are all explained as 'forced movements' and that terms such as 'instinct' and 'self-preservation' can be viewed in terms of chemical mechanisms. To cite one example, Loeb was able to cause the eggs of sea urchins to begin embryonic development without sperm. This was achieved by slight chemical modifications of the water in which the eggs were kept, which served as the stimulus for the development to begin. Similarly, in 1926 Russian physiologist Ivan Pavlov argued that instinct is a 'reflex' and that, for example, the tendency to collect money in man is the result of an instinctive reflex.

Later studies, such as 'imprinting', conducted by Karl von Frisch, Nikolaas Tinbergen, and Konrad Lorenz, who together received the 1973 Nobel Prize in Physiology or Medicine for 'their discoveries concerning organization and elicitation of individual and social behavior patterns', further stimulated theories on human bonding.[28] To pay tribute to these early bonding theory pioneers we will touch on a few of their biographies.

Melanie Klein

Melanie Klein (1882-1960) was an Austrian-born British psychoanalyst, and one of the founders of psychodynamics, who devised therapeutic techniques for children with great impact on contemporary methods of childcare and rearing.[29]

Born in Vienna of Jewish parentage, Melanie Klein first sought psychoanalysis for herself with Hungarian psychoanalyst Sándor Ferenczi when he was living in Budapest during World War I. There she became a psychoanalyst and began analyzing children in 1919. Two years later, she moved to Berlin where she studied with and was analyzed by German psychoanalyst Karl Abraham, a correspondent of Sigmund Freud. Although Abraham supported her pioneering work with children, neither Klein nor her ideas received much support in Berlin. Impressed by her innovative work, however, British psychoanalyst Ernest Jones invited Klein to come to London in 1926, where she worked until her death in 1960.[29]

As a divorced woman whose academic qualifications consisted of a teaching degree, Klein was a visible iconoclast within a profession dominated by male

physicians. Although she questioned some of the fundamental assumptions of Sigmund Freud, Klein always considered herself a faithful adherent to Freud's ideas. Klein was the first person to use traditional psychoanalysis with young children. She was innovative in both her techniques, e.g. working with children using toys, and her theories in infant development. Strongly opinionated and demanding loyalty from her followers, Klein established a highly influential training program in psychoanalysis. Considered one of the cofounders of *object relations theory*, i.e. a theory in psychodynamics in which the ego-self exists only in relation to other objects that may be external or internal, Klein and her followers have had a lasting influence upon child psychology and psychoanalysis.[30]

Apart from her successful introduction of triumphant psychoanalytic concepts, Klein's life was full of tragic events. She was the product of an unwanted birth and her parents showed her little affection. Her much loved elder sister died when Klein was four, and she was made to feel responsible for her brother's death in the years to follow. Her academic studies were interrupted by marriage and children. Her marriage failed and her son died, while her daughter, the well-known psychoanalyst Melitta Schmideberg, fought her openly in the British Psychoanalytic Society and immigrated to America. Mother and daughter were not reconciled before Klein's death, and Schmideberg did not attend Klein's funeral.[31]

Klein's theoretical work gradually came to be centered on Freud's highly speculative hypothesis that life may be an anomaly, that it is drawn toward an inorganic state, and therefore, in an unspecified sense, contains an instinct to die. In psychological terms *Eros*, the sustaining and uniting principle of life, is thereby postulated to have a companion force, *Thanatos*, which seeks to terminate and disintegrate life.[32]

Freud's ideas concerning children mostly came from working with adult patients but Klein tried to allow children to express their own emotion. Klein took notice of children's play as a mode of communication and considered this as a possible site of therapeutic intervention. After observing troubled children playing with toys such as dolls, animals, pencils, and paper, Klein attempted to interpret the specific meaning of play. She discovered that parental figures played a significant role to the child's fantasy life and that the chronology of Freud's *Oedipus complex*, i.e. a theory referring to a stage of psychosexual development where a child of either gender regards the parent of the same gender as an adversary, and competitor, for the exclusive love of the parent of the opposite gender, was imprecise.[33] Contradicting Freud, she concluded that the superego was present long before the Oedipal phase.[34]

Examining ultra-aggressive fantasies of hate, envy, and greed in very young, very ill children, Klein put forth the interpretation that the human psyche is in a constant oscillation depending on whether *Eros* or *Thanatos* is in the fore. She calls the state of the psyche, when the sustaining principle of life is in domination, the

depressive position.[35] The psychological state corresponding to the disintegrating tendency of life she gives the name the *paranoid-schizoid position*.[36]

Melanie Klein's insistence on regarding aggression as an important force in its own right when analyzing children brought her into conflict with Anna Freud, the other major child psychotherapist working in England at the time. Many controversies arose from this conflict.[29]

Karl von Frisch

Karl von Frisch (1886-1982) was an Austrian ethologist noted for his work and research in decoding bee language.[37] He studied zoology with Richard Hertwig, a German zoologist notable as the first to describe zygote formation as the fusing of spermatozoa inside the membrane of an egg cell during fertilization, whom he later succeeded as a professor of zoology at Munich, Germany.[38] In 1923, he began studying the senses of bees, and later identified their mechanisms of communication and showed their sensitivity to ultraviolet and polarized light. His central work was the study of the sensory perceptions of the honeybee and was he one of the first who translated the meaning of the waggle dance.

In beekeeping and ethology, the *waggle dance* is a term used for a particular figure-eight dance of the honeybee.[39] By performing this dance, successful foragers can share with their hive mates information about the direction and distance to patches of flowers yielding nectar or pollen, or both, and to water sources. Thus, the waggle dance is a mechanism whereby successful foragers can recruit other bees in their colony to good locations for collecting various resources.[39] In other words, the waggle dance is a mechanism of social bonding and information transmission in bees. In human terms, we can extrapolate this to the effect that when couples dance, they are conveying subtle unconscious information about their state of mind, thought disposition, and ulterior motives.

On the heels of Frisch's work, were the 1935 birth visual attachment studies of Austrian Zoologist Konrad Lorenz who established the concept of *imprinting*, which is a rapid learning process that takes place early in the life of a social animal, such as in goslings and ducklings, and establishes a behavior pattern, as recognition of and attraction to its own kind or a substitution.[40]

Konrad Lorenz

Konrad Lorenz (1903-1989) was an Austrian zoologist, animal psychologist, and ornithologist. He is often regarded as one of the founders of modern ethology, developing an approach that began with an earlier generation, including his teacher German biologist Oskar Heinroth.[41] Lorenz studied instinctive behavior in animals, especially in greylag geese and jackdaws.[42] Working with geese, he rediscovered the

principle of imprinting in the behavior of nidifugous birds, a behavior noted originally by English biologist Douglas Spalding in the 19th century.[43]

In psychology and ethology, *imprinting* is the term used to describe any kind of phase-sensitive learning that, especially occurring at a particular age or stage, is rapid and apparently independent of the consequences of behavior. It was first used to describe situations in which an animal or person learns the characteristics of some stimulus, which is therefore said to be 'imprinted' onto the subject.

The best-known form of imprinting is *filial imprinting*, in which a young animal learns the characteristics of its parent. It is most obvious in nidifugous birds, who imprint on their parents and then follow them around. It was first reported in domestic chickens, by the 19th century amateur biologist Douglas Spalding.[44] It was rediscovered by Heinroth, and studied extensively and popularised by his disciple Lorenz working with greylag geese.

Lorenz demonstrated how incubator-hatched geese would imprint on the first suitable moving stimulus they saw within what he called a 'critical period' of about 36 hours shortly after hatching. Famously, the goslings would imprint on Lorenz himself or more specifically on his wading boots, and he is often depicted being followed by a gaggle of geese who had imprinted on him:



Lorenz's 1937 *imprinting* experiments with geese

Filial imprinting, however, is not restricted to animals that are able to visually follow their parents; in child development, the term is used to refer to the process by which a baby learns who its mother and father are. The process is recognised as beginning in the womb, when the unborn baby starts to recognize its parents' voices.[45]

Imprinting, according to Lorenz, 'has a number of features which distinguish it fundamentally from a learning process. It has no equal in psychology for any other animal, least of all a mammal.'[46] The four distinct properties that Lorenz attributed to imprinting are: (1) it takes place *only* during a brief critical period in the life-cycle, (2) that it is *irreversible*, (3) that it is *supra-individual learning*, and (4) that it *influences patterns of behavior that have not yet developed* in the organism's repertoire, e.g. the selection of a sexual partner.[47] Lorenz also identified imprinting as the learning that occurs in a young bird in the course of the particular activity of

following a moving object. By 1965, however, further research had shown that neither the critical period nor the irreversibility is as clear-cut as Lorenz had supposed; and that imprint-style learning is not solely a function of object following.[47]

In modern terms, *imprinting*, according to attachment theory pioneer, American developmental psychologist John Bowlby, who studied Lorenz's theories, refers to 'whatever processes may be at work in leading the filial attachment behavior of a young bird or mammal to become directed preferentially and *stably towards* one or more discriminated figures.' The term stability used here is that referring to the quantum electrodynamic evolution movement tendencies of atomic and molecular systems as they seek to satisfy the octet rule, approximately, and the combined law of thermodynamics, exactly. By extension, according to Bowlby, attachment may also be used to refer to 'processes that lead to other forms of behavior to be directed preferentially towards particular objects, for example maternal behavior towards particular young and sexual behavior towards particular mates.'[47]

In mating behavior research, *sexual imprinting* is the process by which a young animal learns the characteristics of a desirable mate. Male zebra finches, for instance, appear to prefer mates with the appearance of the female bird that rears them, rather than mates of their own type.[48] Sexual imprinting on inanimate objects is a popular theory concerning the development of sexual fetishism.[49] In this manner, for instance, imprinting on shoes or boots in a person's early development would be the cause of shoe fetishism.[50]

In an opposite sense, *reverse sexual imprinting* is where two unrelated children live in close domestic proximity during the first few years of life and as such become desensitized to later close sexual attraction. This phenomenon, also known as the 'Westermarck effect', was first formally described by Finnish philosopher and sociologist Edvard Westermarck.[51] The Westermarck effect has since been observed in many places and cultures, including in the Israeli kibbutz system, and the Chinese Shim-pua marriage customs, as well as in biological-related families, and is often attributed to a type of scent de-imprinting.

In the case of the Israeli kibbutz farms, children were reared somewhat communally in peer groups, groups based on age, not biological relation. A study of the marriage patterns of these children later in life revealed that out of the nearly 3,000 marriages that occurred across the kibbutz system, only fourteen were between children from the same peer group. Of those fourteen, none had been reared together during the first six years of life. This result provides evidence not only that the Westermarck effect is demonstrable, but that it operates during the *critical period* from birth to the age of six.[52]

Lorenz's pioneering work originally appeared mainly in journal articles, written in German. Soon, however, his imprinting theories became widely known to English-speaking scientists through the descriptions of them in Dutch ethologist

Nikolaas Tinbergen's 1951 book *The Study of Instinct*, though many of his papers were later published in English translation in the two volumes titled *Studies in Animal and Human Behavior*.[53]

Nikolaas Tinbergen

Nikolaas Tinbergen (1907-1988) was a Dutch ethologist and ornithologist noted for his theories on animal behavior, which he regarded as a reaction. Specifically, 'all behavior', according to Tinbergen, 'is a reaction in so far as it is, to a certain extent, dependent on external stimulation.' Moreover, behavior 'is spontaneous in so far as it is also dependent on internal causal factors, or motivational factors, responsible for the activation of an urge or drive.'[54]

Tinbergen, similar to Lorenz, is well known for originating the four questions he believed should be asked of any animal behavior, which can be subdivided into proximate and ultimate mechanisms:

Proximate Mechanisms

1. Causation (force): what are the stimuli that elicit the response, and how has it been modified by recent learning? How do behavior and psyche function on the molecular, physiological, neuro-ethological, cognitive and social level, and what do the relations between the levels look like?

2. Development (ontogeny): how does the behavior change with age, and what early experiences are necessary for the behavior to be shown? Which developmental steps, in which the ontogenesis follows an inner plan, and which environmental factors play when or which role?

Ultimate Mechanisms

3. Evolution (phylogeny): how does the behavior compare with similar behavior in related species, and how might it have arisen through the process of phylogeny? Why did structural associations, in which behavior can be seen as a time space structure, evolve in this manner and not otherwise?

4. Function (adaptation): how does the behavior impact on the animal's chances of survival and reproduction?

In human chemistry, these questions are to be addressed from the human molecular point of view, i.e. how do they relate to bond formations, dissolutions, and thermal-driven dynamic evolution?

In short, the force that stimulates the response is the electromagnetic force; the organism develops in accordance with the combined law [4.27]; in each phylum, similar behaviors will aggregate so to minimize attraction and repulsion tendencies; in terms of function and adaptation, a molecule's purpose is to react. How the force acts to trigger a reaction in the animal molecule, likewise, will depend on the internal

atomic state of the individual, e.g. stable or unstable in regards to the stimulus, which thus acts as mediator between the force and the spontaneity of the response.

In ethology and sociobiology, questions of causation and ontogeny are summarized as the *proximate mechanisms*, and questions of adaptation and phylogeny as the *ultimate mechanisms*. In modern use, these are the four central questions asked in sciences, such as ethology, sociobiology, and human sciences, in relation to animal and human behavior.[55]

Sigmund Freud

At the turn of the 20th century, Austrian psychologist Sigmund Freud had earlier theorized, as based on the German physicist and physician Hermann von Helmholtz' 1863 version of the first law of thermodynamics, i.e. 'the quantity of *force* which can be brought into action in the whole of Nature is unchangeable, and can neither be increased nor diminished', that sensory forces go into a person and drive them, and that the human personality has three distinctive and interacting parts in which these input energies are conserved and displaced within the mind until finding *mental cathexis*, i.e. the investment of mental or emotional energy in a person, object, or idea.[56] Freud argued, correctly, that these motive forces, in the form of conscious and unconscious energies, drive us.

Originally, Freud had placed the sexual instinct, *Eros* or the libido, centre stage, in explaining the forces that drive us to act. In 1920, however, in his turning-point publication *Beyond the Pleasure Principle,* Freud went beyond the simple pleasure principle, where he developed his 'theory of drives', by adding the death instinct, often referred to as *Thanatos*, although Freud himself never used this term.

The *pleasure principle*, according to Freud, drives one to seek pleasure and to avoid pain. Freud later, however, came to distinguish between those desires that give immediate gratification verses the desires that yield deferred gratification, the latter to which he penned the name the 'reality principle'. Said another way, in Freud's view, as one matures one begins to learn the need, in some cases, to endure pain and to defer gratification because of the exigencies and obstacles of reality. Hence, as Freud states, 'an ego [the working mind] thus educated has become *reasonable*; it no longer lets itself be governed by the pleasure principle, but obeys the *reality principle*, which also at bottom seeks to obtain pleasure, but pleasure which is assured through taking account of reality, even though it is pleasure postponed and diminished.'

The main importance of Freud's 1920 essay resides in the striking picture of the human organism, struggling between two opposing instincts or drives, namely *Eros* working for creativity, harmony, sexual connection, reproduction, and self-preservation, and *Thanatos* for destruction, repetition, aggression, compulsion, and self-destruction. In modern terms, we understand that the two thermodynamic

(energy) drives in life are the *enthalpic drive*, i.e. that related to reaction energy, particularly sexual heat, and the *entropic drive*, i.e. that related to organizational energy, particularly a need or desire to find order.

In 1923, building on precursory theories in *Beyond the Pleasure Principle* essay, Freud published the groundbreaking paper *The Ego and the Id* in which he divided the mind into three parts and explained how one's mental drives operate in the three parts of the mind to create mental dynamics. Interestingly, that same year, Gilbert Lewis and Merle Randall published their famous *Thermodynamics and the Free Energy of Chemical Substances*, in which they elegantly showed how there are three thermodynamic drives (entropy and enthalpy being a function of free energy) that operate in chemical reactions and that, in their own words, 'a thermodynamic system is stable when no process can occur with a diminution in free energy'. Moreover, they state 'by a rough analogy to mechanics we may think of the quantity $-\Delta G$ as the *driving force* of a reaction, while the factors which retard a possible process may be likened to friction.' Here, quite humorously, in the same year of publication, all three authors are talking about the exact same thing, although each is unaware of the other's work. This, however, happens quite often in science.

In any event, Freud notes that often an 'idea' or wish or desire to do or act, once conscious and at the fore in the mind, may quickly disappear and may lie dormant if at ever to return, Freud states that 'the reason why such ideas cannot become conscious is that a certain *force* opposes them, that otherwise they could become conscious'. He continues, in excellent style, using basically straight thermodynamic metaphors:

> "The *state* in which the ideas existed before being made conscious is called *repression,* and we assert that the *force* which instituted the repression and maintains it is perceived as resistance [of] the *work* of [the person]."

Here, Freud is outlining the view that the thrust of one's drives result from unstable, repressed, or unconscious states of the mind to which the person must overcome 'resistances' in the course of their work in family and in society. In updated terms, the measure of the work output of the person in his or her system is the change in the Gibbs free energy. Hence, in terms of physics analogies, Freud correctly stated what today we understand in quantum mechanical thermodynamic exactness.

Freud continues 'we see, however, that we have two kinds of unconscious, the one which is latent but capable of becoming conscious, and the one which is repressed and which is not, in itself and without more ado, capable of becoming conscious.' He defines this as 'psychical dynamics', i.e. *psychodynamics* in modern terms, and by virtue of this one-part conscious, two-part unconscious mind structure

necessity he assigned three terms to quantify the dynamics of these three mental resiliencies, namely:

- **Ego** – the coherent organization of mental processes; the part to which the *conscious* is attached, i.e. the surface of the mental apparatus; the part that controls the approaches to *motility*, i.e. to the discharges of excitations into the external world; the mental agency that assimilates constituent processes of the impulses of mind and the restrictive constraints of the environment. From this area, proceed the repressions, by which is sought to exclude certain trends in the mind not merely from consciousness but also from other forms of effectiveness and activity. Mental resistances emanate from this area.

- **Id** – the part of the unconscious mind that is the source of psychological energy derived from instinctual needs and drives. It is the source of instinctive impulses that seek satisfaction in accordance with the *pleasure principle* and are modified by the *ego* and the *superego* before they are given overt expression. Is the part of the mind associated with instinctual, repressed, or antisocial desires, usually sexual or aggressive and demands for immediate satisfaction of primitive needs. In its efforts to satisfy these desires, the id comes into conflict with the social and practical constraints enforced by the *ego* and *superego.*

- **Superego** – the part of the mind that incorporates family or community values and standards and acts as an inner check on behavior. It is formed in early life by internalization of the standards of friends, family, and other models of behavior. It and the *ego*, responding to social demands, are often in conflict with the primitive impulses of the *id* and in a way, it controls the impulses of the id. It the part of the personality representing the conscience. It censors and restrains the ego and has identified itself unconsciously with important persons from early life. It results from incorporating the values and wishes of these persons into one's own standards. It is only partly conscious, represents internalization of parental conscience and the rules of society, and functions to reward and punish through a system of moral attitudes, conscience, and a sense of guilt.

In sum, Freud's view is such that sensory stimuli are first stored in the mind in the form of *sensory residues*, e.g. visual residues, verbal residues, tactile residues, etc., which thus function in the *id* to create *mental energy*, energies that are effected in the interior of the mental apparatus as this energy proceeds on its way towards action. This energy, after being modified and put in check by the restraints of the *superego*, thus finds release through the conscious working mind otherwise known as the *ego*.

Moreover, as Freud points out, not all sensor inputs are the same. In terms of environmental stimuli, there are both pleasurable and un-pleasurable sensory inputs, both of which impel towards change via dynamic mental *energy cathexis*. The latter types of sensory inputs, i.e. those which are displeasureable, however, according to Freud, result in the greatest amount of mental energy cathexis. In his own words:

> “Sensations of a pleasurable nature have not anything inherently impelling in them, whereas *unpleasurable* ones have it in the highest degree.”

In human thermodynamic terms, in the course of typical human reactions, such as [4.28] or [4.29], a great deal energy is released due to the enthalpic drive, which can be approximated as sexual desire, or the *id*. This total amount of sexual energy competes with the restrictions placed on it by the second law of thermodynamics encapsulated by the effects of the entropic drive, which relates to changes in the ordering of the system, and thus to the *superego*. The sum of these two competing effects is the totality of the work output of the person, couple, or system as personified by the conscious ego and quantified by changes in the Gibbs free energy of the reactive system during the course of its evolution process.

Freud broke down his dynamic personality theory from parts that cannot be directly observed into a tangible model of energy heating water and being released as steam. Freud examined the first law of thermodynamics and applied this to his psycho-dynamics theories as it relates to psychological energy, where knowing that the first law can also be stated as ‘energy can neither be created nor destroyed’.[57]

Freud theorized this to be true with the human personality and adopted Charles Darwin’s assumption that emotion is a form of physical energy.[58] Hence, ‘psychic energy’ can neither be created nor destroyed, it can only be converted from one form to another.[59] He believed that much of one’s personalities are shaped from one’s childhood experiences. He theorized that from a child’s birth until the child has gone through puberty, he or she goes through psychosexual stages of development. The id's ‘pleasure seeking energy’ centers on different pleasure-sensitive zones of the body during different stages in a child's life.

Freud states, in 1923, that this is like ‘a demonstration of the theorem that all knowledge has its origin in external perception’. Likewise, as James Maxell stated, in 1847, ‘the only thing which can be directly perceived by the senses is a force.’ To tie these fundamental postulates together, as Rodger Bacon famously declared, in 1597, all ‘knowledge is power.’ This, in turn, culminated with Sadi Carnot’s 1824 publication *On the Motive Power of Fire*, the inception paper of thermodynamics, on which Freud built his dynamic psychology. In thermodynamics, *motive power* is an agency, as coal, water, or steam, used to impart motion or, generally, a natural agent, such as water, steam, wind, electricity, etc., used to impart motion to machinery, a motor, or a mover. The term may also define something, as a locomotive or a motor, which provides motive power to a system. In current use, *motive power* may be thought of as a synonym for either *work*, i.e. force times distance, or *power*, an effect producing motion, depending on the context of the discussion. Hence, according to Bacon, Maxwell, and Freud, the force of knowledge of one’s immediate sensory environment drives one to work.

Anna Freud

Anna Freud (1895-1982) was the sixth and last child of Sigmund and Martha Freud. Born in Vienna, she followed the path of her father and contributed to the newly born field of psychoanalysis. Anna's work emphasized the importance of the 'ego', and its ability to be trained socially.[23]

Anna, who furthered Sigmund's theory, herself did not have a very close bond with her mother and had difficulties getting along with her siblings, specifically with her sister Sophie Freud. Sophie, who was the prettiest child, represented a threat in the struggle for the affection of their father. Apart from this rivalry between the two sisters, Anna had some other difficulties growing up. Out of correspondence between father and daughter, it can be concluded today that Anna suffered from a depression, which caused eating disorders. The relationship between Anna and her father was different from the rest of her family; they were very close. She was a lively child with a reputation for mischief. In 1899, Freud wrote to his good friend Wilhelm Fliess, a German otolaryngologist who practiced in Berlin, that 'Anna has become downright beautiful through naughtiness...', Sigmund was very proud of his daughter. He mentioned her in his diaries more than others in the family.[23]

Anna began school in 1901 and later Anna would say that she didn't learn much in school but all the more from her father and his guests at home. This way she picked up languages as Hebrew, German, English, French, and Italian. At the age of 15, she started reading her father's work. At a young age, she started to tell her father her dreams and he would publish them in his book *Interpretation of Dreams*. Anna finished her education at the Cottage Lyceum in Vienna in 1912. Suffering from a depression, she was very insecure about what to do in the future. Subsequently, she went to Italy to stay with her grandmother.[23]

In 1923, she began her own psychoanalytical practice with children and two years later, she was teaching at the Vienna Psychoanalytic Training Institute on the technique of child analysis. From 1925 until 1934, she was the Secretary of the International Psychoanalytical Association while continuing with child analysis, seminars, and conferences on the subject. In 1935, Anna became director of the Vienna Psychoanalytical Training Institute and in the following year she published her influential study of the 'ways and means by which the ego wards off displeasure and anxiety', *The Ego and the Mechanisms of Defense*. It became a founding work of *ego psychology,* i.e. the function and operation of the ego with relation to reality-testing, impulse-control, judgment, affect tolerance, defense, and synthetic functioning, and established Anna's reputation as a pioneering theoretician.[60]

In 1938, the Freuds had to flee from Austria as a consequence of the Nazis' continuous harassment of Jews in Vienna. Her father's health was getting bad due to a severe jaw cancer infection, so she had to organize the family's emigration to London. Here she continued her work and took care of her father, who finally died in

the autumn of 1939. When Anna arrived in London, a conflict emerged between her and Melanie Klein regarding developmental theories of children. This conflict threatened to split the British Psychoanalytical Society, but ended in training courses given from two different points of view.[23]

The war gave Anna opportunity to observe the impact of deprivation of parental care on children. She set up a centre for young war victims, called *The Hampstead War Nursery*. Here the children got foster care although mothers were encouraged to visit as often as possible. The underlying idea was to give children the opportunity to form attachments by providing continuity of relationships. This was continued, after the war, at the *Bulldogs Bank home*, which was an orphanage, run by colleagues of Anna and was taking care of children who survive concentration camps. Based on these observations Anna published a series of studies with her lifelong friend, Dorothy Burlingham on the impact of stress on children and the ability to find substitute affections among peers when parents cannot give them.

In the 1940s, Anna and Burlingham made the first documented observations of how young infants and mothers behave when separated (detached) and reunited (re-attached).[61] In 1947, Anna and neuro-psychologist Kate Friedlaender established the Hampstead Child Therapy Courses.[62] Five years later, a children's clinic was added. Here they worked with Anna's theory of the developmental lines. Furthermore, Anna started lecturing on child psychology. Until then, child analysis had remained a quite uncharted territory. Psychoanalysts Siegfried Bernfeld and August Aichorn, who both had practical experience of dealing with children, mentored her in this.

In 1965, Anna had pointed out the virtues of tactile stimulation to infant development and bonding by stating that ‘in the beginning, being stroked, cuddled, and soothed by touch libidinizes the various parts of the child’s body, helps to build up a healthy body image and body ego, increases its cathexis with narcissistic libido, and simultaneously promotes the development of object love by *cementing the bond* between child and mother.’[63] Moreover, she argues that, during this period, the surface of the skin as an erotogenic zone fulfills a multiple function in the child’s growth.

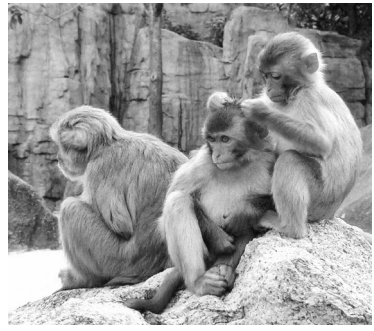
In 1973, in her classic book *Beyond the Best Interests of the Child,* coauthored with Joseph Goldstein, Albert Solnit, and Dorothy Burlingham, Anna argues that children separated from their parents can form bonds of attachment with other adults who fulfill the role of parent and that the longer children are away from their biological parents, the more likely they will bond with their new ‘psychological parents’.[64] Moreover, according to this psychological parent theory, moving children after these bonds have formed causes emotional damage.[65] Yet, in modern terms, this logic conflicts between data which show, for instance, that children in foster care suffer psychological harm when they are cut off from their family and that they benefit from contact with their parents during placement.[65]

Harry Harlow

Harry Harlow (1905–1981) was an American early developmental psychologist best known for his maternal-deprivation and isolation experiments on rhesus monkeys, which demonstrated the importance of care-giving and companionship in the early stages of primate development.[66] He conducted most of his research at the University of Wisconsin, where he worked for a time with humanistic psychologist Abraham Maslow.[67] In his most popularized series of experiments, conducted between 1963 and 1968, Harlow offered young rhesus monkeys a choice between two surrogate 'mothers', either a cloth-one without food or a wire-one with food.

In the first group, the terrycloth mother provided no food while the wire mother did, in the form of an attached baby bottle containing milk. In the second group, the terrycloth mother provided food; the wire mother did not. It was found that the young monkeys clung to the terrycloth mother whether it provided them with food or not and that the young monkeys chose the wire surrogate only when it provided food. Apparently, the terrycloth mothers provided something that was more valuable to the young monkeys than food. She was providing contact comfort. Harlow's interpretation was that the preference for the terrycloth mother demonstrated the importance of affection and emotional nurturance in mother-child relationships.

Whenever a frightening stimulus was brought into the cage the monkeys ran to the cloth mother for protection and comfort no matter which mother provided them with food. This response decreased as the monkeys grew older.[66]



Bonded rhesus macaques

When the monkeys were placed in an unfamiliar room with their cloth surrogates, they clung to it until they felt secure enough to explore. Once they began to explore they would occasionally return to the cloth mother for comfort. Monkeys placed in an unfamiliar room without their cloth mothers acted very differently. They would freeze in fear and cry, crouch down, or suck their thumbs. Some of the monkeys would even run from object to object, apparently searching for the cloth mother as they cried and screamed. Monkeys placed in this situation with their wire mothers

exhibited the same behaviors that the monkeys with no mother accompanying them did.[66]

Once the monkeys reached an age where they could eat solid foods they were separated from their cloth mothers for three days. When they were reunited with their mothers they clung to them and did not venture off to explore as they had in previous situations. Harlow claimed from this that the need for contact comfort was stronger than the need to explore.

The study also found that either monkeys who were raised with a wire mother or a cloth mother gained weight at the same rate. However, the monkeys that had only a wire mother had trouble digesting the milk and suffered from diarrhea more frequently. Harlow interpreted this to mean that not having contact comfort was psychologically stressful to the monkeys. Harlow did eventually try to cure the depressed symptoms visible in monkeys deprived of a real mother through various forms of therapy.

Some of Harlow's experiments involved rearing infant macaques in isolation chambers that prevented them from having any contact with other monkeys or human beings. The monkeys were left alone for up to twenty-four months, and emerged severely disturbed.[244] They also showed abnormal sexual responses. Female monkeys who were raised in isolation often neglected or abused their infants. This abnormal behavior is thought to demonstrate that the instruction, affection and imitation afforded in a *bond* with the mother is necessary for mental and social development. The effects of early exposure to the wire and cloth mothers could be seen roughly two years later, well into the adulthood. The experiment implied young babies without mothers or primary caregivers are likely to have compromised mental and social development.

Harlow first reported his results of these experiments in ‘The nature of love’, the title of his address to the sixty-sixth Annual Convention of the American Psychological Association, Washington, D. C., August 31, 1958.[68] These studies were motivated by John Bowlby's World Health Organization-sponsored study and report, *Maternal Care and Mental Health* in 1950, in which Bowlby reviewed previous surveys of the effects of institutionalization on child development such as those of American psychoanalyst René Spitz and conducted his own surveys on children raised in a variety of settings.[69]

In 1953, Bowlby’s colleague, child development researcher James Robertson, produced a short and controversial documentary film titled *A Two-Year-Old Goes to Hospital* demonstrating the almost immediate effects of maternal separation. Bowlby’s report, coupled with Robertson's film, demonstrated the importance of the primary caregiver in human and non-human primate development.[66]

John Bowlby

John Bowlby (1907-1990) was a British child psychologist in the psychoanalytic tradition, notable for his pioneering work in attachment theory.[70] Bowlby was born in London to an upper-middle-class family. He was the fourth of six children and was raised by a nanny in traditional British fashion of his class. His father, Sir Anthony Bowlby, first Baronet Bowlby, was surgeon to the King's Household, but with a tragic history; at age five, his own father, i.e. John's grandfather, had been killed while serving as a war correspondent in the Anglo-Chinese Opium War.

Normally, John saw his mother only one hour a day after teatime, though during the summer she was more available. She had thought that spoiling her children was dangerous, so that attention and affection was the opposite of what was required with a child. When Bowlby was almost four years old, his beloved nanny, who was actually his primary caretaker in his early years, left the family. Later, he was to describe this as tragic as the loss of a mother.

This significant event is the lynchpin in the entire history of the theory of human bonding. It can easily be argued that if this event were not to have happened, i.e. if the nanny had stayed a few more years, that Bowlby would not have been so driven to understand the attachment process and human bonding, and we would likely not be using the word 'bonding' as much as we do now or if at all. In 2004, for instance, Bowlby's son Richard, states in the preface section to the Routledge reprint edition of Bowlby's classic 1979 book *The Making and Breaking of Affectional Bonds,* that 'I'm sure the making and breaking of affectional bonds had a profound significance for my father. When he was young he was cared for by an affectionate and playful nanny called Minnie, but she left the family when he was four.' Richard continues 'he told me that he was very attached to Minnie and felt the pain of separation when their *affectional bond* was broken, but although his work reminded him of this pain, he was able to work with it throughout his life.'[71]

Initially, Bowlby's intellectual career began at Trinity College, University of Cambridge, where he studied psychology and pre-clinical sciences. He won prizes for outstanding intellectual performance. After Cambridge, he took some time to work with maladjusted and delinquent children, then at the age of twenty-two enrolled at University College Hospital in London. At the age of twenty-six, he qualified in medicine. While still in medical school, he also found time to enroll himself in the Institute for Psychoanalysis. Following medical school, he trained in adult psychiatry at the Maudsley Hospital. In 1937, he qualified as a psychoanalyst and then became president of Trinity College the following year.[72] His first major publication on attachment theory was a 1940 paper called 'influence of early environment in the development of neurosis and neurotic character'.[73]

During World War II, he was a Lieutenant Colonel. After the war, he became the Deputy Director of the Tavistock Clinic and from 1950 the Mental Health

Consultant to the World Health Organisation. Because of his previous work with maladapted and delinquent children, he became interested in the development of children and began work at the Child Guidance Clinic in London. Bowlby was interested in finding out the actual patterns of family interaction involved in both healthy and pathological development. He focused on how attachment difficulties were transmitted from one generation to the next.

The three most important experiences for Bowlby's future work and the development of attachment theory were his work with (1) his work with maladapted and delinquent children, (2) his association with James Robertson and especially in regards to the 1952 documentary film 'A Two-Year Old Goes to the Hospital', which was one of the films about young children in brief separation illustrating the impact of loss and suffering experienced by young children separated from their primary caretakers, and (3) the his interaction with Melanie Klein during his psychoanalytic training, who was his supervisor; they, however, had different views about the role of the mother in the treatment of a three-year-old boy.[72]

Following Lorenz's discovery of imprinting in Geese and other *precocial animals*, i.e. those capable of a high degree of independent activity following birth, and Tinbergen's development of the four questions, American developmental psychologist John Bowlby was asked by the World Health Organization to look into the effects of separation of infants from mothers. The result was the 1951 precursory attachment-theory book *Child Care and the Growth of Love*, which was effectively an abridged version of a report written for the World Health Organisation that same year.[74]

To investigate these separation effects, Bowlby studied the cases of 44 juvenile delinquents. He found that 17 had been separated from their mother for some time before the age of five. This was significant compared to the control group (also 44). Bowlby concluded that maternal deprivation could result to seriously effect a child's mental health. To explain this, he developed a 'theory of monotrophy' for humans, similar but different to animal imprinting and proposed that a young infant forms an *attachment* with its mother during first six months of life. Moreover, he assumed that the mother-child relationship was qualitatively different as compared to others. Two of his subjects, for example, had very little social conscience. He described this as affectionless psychopathy, reasoning that attachment failure resulted in a failure to develop social conscience: 'what is believed to be essential for mental health is that the infant and young child should experience a warm, intimate and continuous relationship with his mother, or permanent mother-substitute, in which both find satisfaction and enjoyment'.

By 1953, Bowlby clearly had outlined the importance of the maternal bond in relation to child its mother.[75] Stemming from ideas in these various publications, 'attachment theory' was soon conceived as a psychological theory about the evolved adaptive tendency to maintain proximity to an attachment figure.[76] The basic origin

of attachment theory can be traced to the publication of two papers, one being Bowlby's 1958 'the Nature of the Child's Tie to his Mother', in which the precursory concepts of attachment were introduced, and American psychologist Harry Harlow's 1958 'the Nature of Love', which was based on the results of experiments which showed, approximately, that infant rhesus monkeys preferred emotional attachment over food.[77]

In the decades to follow, Bowlby began to collaborate with British psychiatric social worker James Robertson, who focused his research on separations of mother and child due to hospital admission. Between the two of them, they derived a classic theory about the phases of protest, despair and denial, through which small children pass when isolated from their mothers for a length of time. Bowlby called this last stage *detachment*.[78] In 1971, Robertson, in coordination with his wife Joyce, began to publish influential articles in which they began to use the term *bonding* for parent-to-infant attachment.[79] Prior to this, the term bonding had been used sparingly. In a 1964 issue of the *Journal of Marriage and Family* by the National Council on Family Relations, one can find statements such as 'sociologists are able to analyze the process of bonding.'[80]

In sum, the most famous and enduring work of John Bowlby was theorizing about attachment styles of infants with primary caretakers. He observed and generalized from his observations, and hence developed a scientific theory of attachment. In his view, attachment behavior was an evolutionary survival strategy for protecting the infant from predators, and attachment theory reflects that. In the years to follow, Mary Ainsworth, a student of Bowlby's, further extended and tested his ideas.[77]

James and Joyce Robertson

James Robertson (1911-1988) was a Psychiatric Social Worker and Psychoanalyst, based at the Tavistock Clinic, best known for his 1950s films of children separated from their mothers in hospital settings.[81] Joyce Robertson, his wife of near fifty years, was a student at the *Anna Freud Wartime Nurseries*, and worked at the Anna Freud centre from 1956 until joining her husband in 1965 to work at the Tavistock Clinic.[21] Together, through their various writings an publications, they were the two individuals who most helped to stimulate the use of the word 'bonding' as we currently use it.

James was born in Glasgow where he grew up in a closely-knit working class family. In his late teens, he became a Quaker. In his twenties, he met and married Joyce. When the war broke out he registered as a conscientious objector and joined the Pacifist Service Unit in the East End of London in 1940, working with the victims of the bombing.[21] In 1941, they joined Anna Freud in the Hampstead Wartime Nurseries. Joyce, during this period, was a student caring for the infants

who had lost family due to the war. James began by organizing the maintenance and coordinating the fire-watching efforts.

During this period, Anna taught them about the psychological development of young children, a teaching that functioned as the theoretical basis for their later publications on parent-infant bonding. In the following years, James received a social science diploma and began taking psychiatric social worker courses at the London School of Economics in 1947. After the war, in 1948, James, now trained as a psychiatric social worker, joined John Bowlby at the Tavistock Clinic to make observations on separated young children, observations that were to be used in Bowlby's theoretical writings. During this period, James trained as a psychoanalyst, sponsored by Anna Freud.

In his studies, to gather data on childcare protocol used in hospitals, he went to the short stay children's ward at the Central Middlesex Hospital in London. In these years, children would often be admitted to hospitals and then immediately shut off from contact with their parents for fear that the parents would be potential carriers of infections and secondly so that the young children would be given time to adjust to the fact that they would not, in their minds, potentially see their parents any more and thus stop crying a factor that would maintain the smoothness of the operation of the hospital.

During one of his visits to the hospital, it was explained to James that every young child admitted to the hospital began by crying for the mother, perhaps by rattling their cot. But, as James was told, within a few hours or a few days the child would 'settle down', i.e. they would 'forget' their mother and that every child settled in time and became quite and uncomplaining.[21] In addition, after a child was indoctrinated into the existence of isolation, it was found that if a nurse stopped beside a silent toddler, he or she would usually burst into tears at the human contact and the nurse would be rebuked for 'making the child unhappy'. In these years, a quiet ward was prized above all else, so nurses kept away from recently admitted young patients except to feed and clean them.[21]

James knew that this caused great distress to young patients, especially those aged three and under, and that it was also common knowledge in the community that young children could be 'changed' by a stay in a hospital. It was James mission to study this change, to document it on film, and to theorize about the non-functionality of this process from a psychodynamic attachment point of view.

In 1957, Joyce stayed home until both of their daughters were settled in school, after which she returned to work at the Anna Freud Center, observing mothers and babies in the Well Baby Clinic, and later in a residential nursery. In 1965, Joyce joined James at the Tavistock Clinic to do research on young children in brief separation. James stayed at the Tavistock Clinic until 1975, after which they, being semi-retired, formed the Robertson Centre. Their two most influential publications are the 1971 'Quality of substitute care as an influence on separation responses' and

the 1972 'Young children in brief separation: a fresh look'.[82] In the 1980s, these two articles stimulated American pediatricians Marshall Klaus and John Kennell to begin using the word 'bonding' over the word 'attachment' in their writing.[27]

Mary Ainsworth

Mary Ainsworth (1913-1999) was an American developmental psychologist known for her work in early emotional attachment with 'The Strange Situation' as well as her work in the development of Attachment Theory.[26]

Ainsworth was born in Glendale, Ohio in 1913, eldest of three sisters. Her parents both graduated from Dickinson College. Her father earned his Masters in History and was transferred to a manufacturing firm in Canada when Ainsworth was five. While her parents always put a strong emphasis on education, it was William McDougall's 1926 book *Character and the Conduct of Life* that inspired her interest in psychology; his theories also influenced Conrad Lorenz.

Ainsworth enrolled in honors program in psychology at the University of Toronto in the fall of 1929. She earned her BA in 1935, her MA in 1936, and her PhD in 1939, all from the University of Toronto. She stayed to teach for a few years before joining the Canadian Women's Army Corp in 1942 in World War II, reaching the rank of Major in 1945. In the years to follow, she returned to Toronto to continue teaching personality psychology and conduct research. She married Leonard Ainsworth in 1950 and moved to London with him to allow him to finish his graduate degree at University College.

While in England, Ainsworth joined the research team at Tavistock Clinic investigating the effects of maternal separation on child development. Comparison of disrupted mother-child bonds to normal mother-child relationship showed that a child's lack of a mother figure leads to 'adverse development effects'. In 1954, she left Tavistock Clinic to do research in Africa, where she carried out her longitudinal field study of mother-infant interaction.

She and her colleagues developed the *strange situation procedure*, which is a widely used, well-researched and validated, method of assessing an infant's pattern and style of attachment to a caregiver. In the strange situation a mother (or other caregiver) and child are separated and reunited twice across eight episodes: 1) the mother and child are placed in a room with toys to explore; 2) a stranger enters; 3) the mother leaves; 4) the stranger leaves; 5) the mother returns and comforts the child; 6) the mother leaves; 7) the stranger enters and attempts to comfort the child; 8) the mother returns and comforts the child. Infants are then classified in one of three categories, based on their behavior on reunion with their mothers.[70]

- **Secure attachment** - If the child protested the mother's departure and quieted promptly on the mother's return, accepting comfort from her and returning to exploration, then the child's relationship to the mother would be classified as a secure attachment.
- **Avoidant attachment** - If the child showed little to no signs of distress at the mother's departure, a willingness to explore the toys, and little to no visible response to the mother's return, then the child-mother relationship would be classified as avoidant.
- **Ambivalent attachment** - If the child showed sadness on the mother's departure, ability to be picked up by the stranger and even 'warm' to the stranger, and on the mother's return, some ambivalence, signs of anger, reluctance to 'warm' to her and return to play, then this child would be classified as ambivalent.

By 1962, after further testing some of Bowlby's ideas with her hypothesis that the attachment figure is a *secure base* from which an infant can explore the world, Ainsworth had fortified attachment theory.[77]

Marshall Klaus and John Kennell

In the 1970s, American pediatricians Marshall Klaus and John Kennell engaged in a number of thought-provoking discussions with James and Joyce Robertson and John Bowlby on the topic of the early attachment process in the development of the parent-child tie.[27] As a result of these exchanges and discussions, along with research such as Ainsworth's strange situation attachment-base theories, and other work, including their own research and publications between the years 1960 and 1975, Klaus and Kennel were stimulated to write the influential 1976 human bonding book *Maternal-Infant Bonding*. Owing to this popular publication, that same year, according to Merriam-Webster, the application of the term 'bonding' to interpersonal relationships came of use. By 1979, sociologists, such as Charles Brown, Paul Keller, in their book *Monologue to Dialogue: an Exploration of Interpersonal Communication*, were using chemical phrases such as 'relationship and human bonding are fundamental to life.'

Humorously, with reference to attachment terminology, in the preface to 1982 second edition of Klaus and Kennell's book, titled *Parent-Infant Bonding*, they state 'we were distressed when the word *bonding* became too popular to rapidly and was confused with a simple, speedy, adhesive property rather than the beginning of a complex human psycho-biological process.' For many months, he says they 'tried to change the terminology to parent-to-infant *attachment*' but that 'James and Joyce Robertson charmingly and convincingly explained to us that the word [bonding] was so well known that it was here to stay.' In the years to follow, the use of the term bonding in infancy began to increase.

Kennell and Klaus' groundbreaking research on mother-infant bonding and the importance of continuous support for pregnant women during childbirth, has resulted to the affect that many hospitals now offer 24-hour visitation to prematurely born or

ill babies, early contact, and 'rooming in' for healthy babies.[27] Their work also has altered the care of pregnant women by introducing the concept of a caregiver known as a *doula*, which are non-medical assistant in prenatal care who attend to the emotional and physical comfort needs of laboring women to smooth the labor process.[27] They do not perform clinical tasks such as heart rate checks, or vaginal exams but rather use massage, aromatherapy, reflexology, positioning suggestions, etc., to help labor progress as well as possible. A labor/birth support doula joins a laboring woman either at her home or in hospital or birth center and remains with her until a few hours after the birth. Some doula's also offer several prenatal visits, phone support, and one postpartum meeting to ensure the mother is well informed and supported.[27]

Their doula-related work helped decrease the length of labor by 25 percent, cut in half the rate of cesarean-section births, and resulted in improved maternal mental health and infant care by the mother. Their research also demonstrated the value of early contact, suckling and rooming in for healthy mothers and babies in markedly improving the success of breast-feeding over a baby's first year of life. This work was part of the basis of UNICEF's 1991 Baby Friendly Initiative, which has been adopted in many parts of the world, including 3,800 hospitals in China, 1,400 in Thailand, and 1,200 in the Philippines.[27]

In the updated 1995 edition titled *Bonding: Building the Foundations of Secure Attachment and Independence*, co-authored with Phyllis Klaus, they delve into more advanced topics such as developing ties during the first days, premature birth and bonding, birth defects and bonding, and de-bonding: the route to independence. They further update their earlier theories with studies that indicate that 'well-bonded' babies, and even younger children (up to age seven), have remarkably higher test scores and better academic grades in school and are more successful overall.

Bond terminology: 1980-present

In 1982, authors Stephen Bank and Michael Kahn, in their popular book *The Sibling Bond*, published the results of their research and findings on sibling bonding and attachment, which, according to these authors, is second only to the parent-infant bond. In the 1987 book *Cognitive Development in Infancy* by John Oates, there are six pages devoted to the concepts of bonding.

In 1984, *Psychology Today* conducted a national survey probing for the relation between humans and pets. Approximately 13,000 people responded to the survey. The following year, structured over the findings of this pet survey, author Marvin Sussman published a 238-page book titled *Pets and the Family* focused on the topic of *human-animal bonding*, its applications, conceptual issues, and research areas. The 1984 national pet survey, according to Sussman, is a landmark survey indicating 'the pervasiveness of the animal-human bond and the extremely high prevalence of

pets in U.S. households.' In this book, Sussman along with a variety of contributors discuss such topics as bond initiation and maintenance, the *preadolescent-pet bond*, human-animal attachment, death of a pet and human response to the breaking of the bond, and others.[83]

By the 1990s, the use of the term bonding in human relationships began to gain momentum. In 1990, sociologists Peter Rossi and Alice Rossi published there 542-page book *Of Human Bonding: Parent-Child Relations Across the Life Course*, in which they discussed their findings from interviews of 1,393 people in the greater Boston area, who were queried on the topic of bonding behaviors in the immediate and extended family and through generations. In 1991, relationship expert Barbara Brothers published her 106-page book *Coupling: What Makes Permanence* followed by her 1994 Bowlby-style 145-page book *Attraction and Attachment: Understanding Styles of Relationships.* In 1992, American anthropologist Helen Fisher argues, in her book *Anatomy of Love – a Natural History of Mating, Marriage, and Why We Stray*, that people have a natural four-year itch in that the tendency to divorce peaks after four years of marriage, whereby, afterwards, marriage-bonds becoming more stable. She finds that from her meta-analysis of sixty-two different cultures, that divorces regularly cluster around a four-year peak and that 'this pattern of *human bonding* is even embedded in Western mythology'. In 1996, author Seiichi Matsumoto published a sociology, anthropology and cultural history perspective book on bonding called *Sexuality and Human Bonding*, containing the presentations from the 12th World Congress on sexology.[84] The 2001 book *The Ontogeny of Human Bonding Systems*, by American psychologists Warren Miller and Joseph Rodgers gives an excellent interdisciplinary look at the phenomena of human bonding that over the years, according to their reference section, has been theorized on mostly from the Bowlby attachment-theory point of view.

In modern times, the ubiquitous use of the chemical term 'bonding', in reference to human relationship variations, has become a commonplace word in modes of relationship discussion, those such as fluid-bonding, adoption-bonding, gay-straight bonding, bug-bonding, baby-bonding, equine-bonding, debonding, etc.[85] In the following sections, we will touch on a few of the basic terms.

Bond varieties

The term 'bonding' applies aptly to all variations of connections within interpersonal relationships, social networks, economic nexuses, political ties, etc. The term *male bonding*, used as early as 1972, refers to bonding between males through shared activities excluding females; or the formation of a close personal relationship between men.[86] A common example of usage is: 'the rituals known as male bonding do not necessarily involve drinking beer together'. Male bonding is a term that is used in ethology, social science, and in general usage to describe patterns of

friendship and or cooperation in men; or in the case of ethology: males of various species. The exact meaning of the term differs across contexts. In ethology, a species is said to have 'male bonding' if the males regularly form coalitions in which they mutually support each other, especially if such coalitions are used to attack other groups or individuals.[87] Sporting events, hunting, poker, gambling, and fraternities are a typical cohesive elements in male bonding.

The analog concept *female bonding*, used as early as 1984, refers to the formation of a close personal relationship between women.[88] In ethology, similarly, a species is said to have 'female bonding' if the females regularly form coalitions in which they mutually support each other, especially if such coalitions are used to attack other groups or individuals.[89] The 2004 film *Mean Girls*, which is based on the non-fiction 2002 book *Queen Bees and Wannabes* by Rosalind Wiseman, which describes how female high school social cliques operate, and the effect they can have on girls, highlights the intricacies of female bonding.[90] One interesting function of female bonding, which differs significantly from male bonding, is that the fervent exchanges in the female bond, through distal and diverse connections, result to hold the fabric of society together.[91]

The *familial bond*, used as early as 1982, defines as a uniting force, tie, or link between related family members.[92] A related concept is 'bondage', being the tenure of service of a villager, serf, or slave and generally refers to a state of being bound by compulsion as via law or mastery; a 'bondmaid' is a woman servant, a 'bondman' is a male servant, and a 'bondsman' is a person who provides bail bonds or surety for another. In the 14th century, a 'bondwoman' was considered a female slave.

A comparable analog is *labor union*, originating in 1866, being an organization of united workers formed for the purpose of advancing its members' interests in respect to wages, benefits, and working conditions. The cohesion of the group is facilitated by the exchange of union dues for benefits. By uniting, the bonded group has more leverage than as compared to a collection of separate individuals.

Similar to the marriage bond, is concept of civil union. A *civil union* is one of several terms for a civil status similar to marriage, typically created for the purposes of allowing same-sex couples access to the benefits enjoyed by married opposite-sex peoples.[93] It can also be used by opposite-sex couples who do not prefer to enter into the legal institution of marriage but who would rather be in a union more similar to a common-law marriage. Beginning with Denmark in 1989, civil unions under one name or another have been established by law in many developed countries in order to provide same-sex couples with rights, benefits, and responsibilities similar to those enjoyed by opposite-sex couples in marriage. In some jurisdictions, such as Quebec and New Zealand, civil unions are also open to opposite-sex couples.[93]

A similar term is *same-sex marriage*, which is a governmentally, socially, or religiously recognized marriage in which two people of the same sex live together as a family.[94] With the popular success of the hit television show *Queer Eye For The*

Straight Guy and others such as *The Ellen DeGeneres Show*, the term 'gay-straight bonding' as well as 'gay bonding' have come into vogue.[95]



Gay bonding: same-sex marriage has been an important legal issue in recent years.

The term *mother-bonded*, refers to a man who remains excessively attached to his mother at an age when men are expected to be independent, e.g. living on their own, being economically independent, etc.[96] This bonding term is often used in situations where a women is in entangled in an unstable relationship with a man who is overly entangled with his mother. Being mother-bonded is seen as a sign of weakness, and has a social stigma attached to it in many places, although outside of North America it maybe more acceptable or perceived as normal. A mother-bonded man is seen to give control of his own life to his mother, in exchange for a sense of security. If the mother has more than one son, then she will tend to have, at most, one mother-bonded son, usually the eldest son.[97] Alternatively, in recent years, some have begun using the term in a milder sense, merely meaning a man who is only emotionally attached to his mother. It is also occasionally used to describe an infant or toddler son who is overly attached to his mother, e.g. crying or resisting when the father attempts to care for him.

In human chemical terms, this phenomenon can be understood from two points of views, namely attachment theory and collision theory.[98] From an attachment theory point of view, it can be argued that male, in certain situations, was not able to detach successfully from the maternal structure. In collision theory terms, to form the requisite bonds of marriage or relationship two human molecules have to collide. In a successful collision, the old bonds will either break or readjust to the new bonds. If, for some reason, the old bonds do not readjust, then, as a result, the new bonds will not be as fervent. In human thermodynamic terms, the activation energy E_A and entropy of activation S_A of the romantic pairing collision are such that the older maternal bonds did not break or transform properly so to allow the formation of the new bonds of the relationship or marriage.

Aside from these common bonding terms, there are other miscellaneous human bonding terminologies that vary per use, language, and culture. *Connectors*, for

example, are people in a community who know large numbers of people and who are in the habit of making introductions.[99] Being *linked* refers to the number of degrees of separation between two people, often categorized in terms of 'nodes' (people) and 'links' (exchanges).[100] A *reciprocal link* is a two way link to and from websites, also known as 'link swaps', 'link exchanges', or 'link partners'.[101] A reciprocal link, generally, is a mutual link between two objects, commonly between two websites in order to ensure mutual traffic. *Three-way linking* is a special case of reciprocal linking in which site-A links to site-B who links to site-C who links site-A. A *one-way link*, a term used among webmasters for link building methods, is a hyperlink that points to a website without any reciprocal link; thus the link goes 'one way' in direction.[102] A *hyperlink* or simply 'link' is a reference or navigation element in a document to another section of the same document, another document, or a specified section of another document, that automatically brings the referred information to the user when the navigation element is selected by the user.[103]

The term *homophily* means love of the same and refers to the tendency of individuals to associate and bond with similar others.[104] This term is basically the same as Plato's law of affinity, i.e. *likes attract unto likes*. Another term is *gemeinschaft*, which is a spontaneous organic social relationship characterized by strong reciprocal bonds of sentiment and kinship with in a common tradition.[105] In popular use, a *clique* is an informal and restricted social group formed by people who share common interests, which are often associated with teenagers.[106] Over the last decade, the term *dyad* or 'dyadic bond' has become a popular term for bonding theory psychologists and sociologists, being used as a synonym or substitute word for the pair bond.[107]

In chemistry, a *molecular chaperone* is any of a group of proteins in living cells that assist newly synthesized or denatured proteins to fold into their functional three-dimensional structures.[108] The chaperones bind to the protein and prevent improper interactions within the polypeptide chain, so that it assumes the correct folded orientation.[109] This process requires energy in the form of ATP. The chemical bond of this interaction is a *regulatory bond*. In human molecular terms, a chaperone is a person, as a matron, who for propriety accompanies one or more young unmarried women in public or in mixed company or is an older person who accompanies young people at a social gathering to ensure proper behavior.[110] In both cases, i.e. protein molecule and human molecule, the bond is the same.

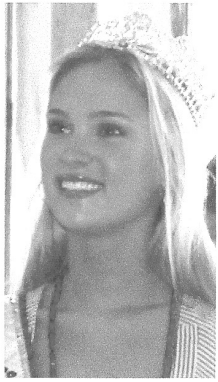
Bond distinctions

A common bipartite division or distinction when referring to the structural integrity of relationships or unions is to divide such bonds via a physical and a neurological component, which may or may not co-occur. In short, the human chemical bond can be divided into two parts:[111]

1. **Physical bond** – two people bonded owing to physical adhesion.
2. **Neurological bond** – two people bonded owing to neurological adhesion.

All human bonds can be divided, by percentage, into their separate physical and neurological components. Highly physically attractive people, such as homecoming queens or models, tend to have 90-to-10 physical-to-neurological composition ratio; whereas, conversely highly neurologically attractive people, such as mathematicians or computer scientists, tend to have 10-to-90 physical-to-neurological composition ratios.[112] The colloquial beauty-brain paradox embodies this division; which derives, essentially, from the inverse relation between heat and order in dynamic molecular systems. The average person will have unique bond composition variations within this spectrum.

A 2004 survey found that, on average, human relationship bonds can be divided into three categories by percentage: *physical* (41%), i.e. the only thing holding the couple together is physical attractiveness, e.g. they like the way the other looks, smells, tastes, etc., nothing more; *neurological* (25%), i.e. the only thing holding the couple together is neurological attractiveness, e.g. they like each other's personality, character, intellect, inner nature, etc., but physically they are not attracted to each other; *both* (34%), i.e. the bonded couple is held together by both physical and neurological attractiveness; i.e. they like each other's looks and like each other's personality, character, intellect, inner nature, etc. Percentages indicate the number out of 100 average couples who are likely to posses that type of relationship bond.[111]



Samantha Casey
Miss Virginia Teen 2006



Dewey Redman
Moers Festival 2006

A beauty pageant winners, models, and centerfolds, etc., embody the essence of physical attractiveness, qualities such as scent, symmetry, averageness, youthfulness, health, complexion, etc., which are all important parts of human bonding. Learned

abilities and talents, such as musical skill, stock market acumen, the ability to teach, etc., similarly, embody the essence of neurological attractiveness, qualities such as ability, drive, intellect, skill, occupational acumen, humor, class, etc., which are also all important aspects of human bonding.

Both the physical and neurological bond are qualified and quantified according to a synergism of both consensus-driven, i.e. social perspectives, and personal views, i.e. individual perspectives, of adhesion measurement. The physical bond, in the most intimate of personal relationships, will be sexual in nature, i.e. a sexual bond. In other cases, it may refer to individuals bonded by proximity as neighbors or by blood as siblings. People bonded physically typically have a visceral connection, linked either via pheromone exchange, visual attraction, tactile affinity, hormonal adhesion, immune system compatibility, etc. The neurological bond relates to all varieties of neurological or mental attachment, referring to psychological bonds, intellectual bonds, emotional bonds, financial bonds, synergistic bonds, altruistic bonds, etc. It is the central nervous system that coordinates all variations of order in life. Two people that have an increased ordering when mixed will adhere better. Neurological adhesions, such as similar personalities, like interests, equivalent intellects, etc., will actuate in the form of a neurological bond. Physical bonds and neurological bonds coordinate to create human chemical bonds.

In the history of the various human bonding theories, this physical-neurological dichotomy has been an ever-present feature. In Stendhal's 1821 classic *On Love*, he delineates the pure intellectual and physical nature involved in the dynamics love, in its numerous variations, with the statement 'to find love in Paris you must go down among those classes where the absence of education and of vanity, and the struggle for bare necessities, have allowed more energy to survive.' Goethe, as mentioned, struggled as well with this paradox, when he outlined the parallels of the relationship between love and social class and the work output per group. In short, the most intense forms of love, according to these authors, are rare in the upper classes, where intellect prevails; whereas, conversely, the purest forms of love exist in those groups where, in the absence of advanced education, a raw physical heat abounds. The 1951 film *A Streetcar Named Desire* comes to mind.

In basic thermodynamic systems where greater heat abounds, disorder tends to prevail; the most ordered systems, conversely, are those where heat is nearly absent, i.e. those temperatures near absolute zero where entropy approaches zero, i.e. perfect order. This basic heat-order / temperature-entropy relation applies in human life and explains why the hottest variations of love are found in lower social classes where disorder prevails as Goethe and Stendhal pointed out. The relation between heat and order also explains the stereotypical inverse connection between the highly ordered neurological nature of geeks and nerds, to use common terms, and their lower levels of physical hotness, on average, as well as the less ordered neurological nature of supermodels and beauties and their higher levels of physical hotness, on average.[113]

To quote a typical colloquial example of this heat-disorder paradox, i.e. brains-beauty relation, in the 2001 comedy film *100 girls*, which is about a college student's efforts to find a mystery girl with whom he had sex in an elevator during a black out, we find Cynthia, the 'hottest' of the 100, who is described as the 'Superbowl of Women', writing notes to herself in her journal.[114] She states 'I'm not stupid. I know I got things easy. Guys will pretty much do anything for me because of the way I look (referring to a guy who did her term paper). It's a curse. You see, nothing is a challenge for me. Everything's made easy. And if I ever actually do, do something on my own, then everyone assumes I got there because of the way I look. It sucks!'[115] The distinction referred to here is that between two competing thermodynamic driving tendencies in evolution: enthalpy (heat) and entropy (order). In other words, those high in personal levels of physical hotness will, on average, tend to lack in personal levels of neurological order, and conversely.[116]

To elaborate further on this human bonding dichotomy between that of mental order (neurological attachments) and superficial heat (physical attachments), in 1939 psychologist Godfrey Thomson, in his *Factorial Analysis of Human Ability*, posited that in human relationships, in addition to the basic physical or visceral connections, there are theoretical 'bonds' of intelligence which function in loving relationships. Similarly, in Robert Sternberg's 1986 *Triangular Theory of Love*, he defined Thomson's theory as a structural model of love where we might conceptualize love in terms of feelings that when sampled together yield the composite experience that we label love. This composite, according to Sternberg is 'not an undifferentiated unity; rather, it can be decomposed into a large number of underlying bonds that tend to co-occur in certain close relationships.'

In recent years, there has been a surge in publications pointing to chemical clues in regards to what specific hormones, neurochemicals, endorphins, pheromones, etc., function in the operation of the human chemical bond. We now know, for example, that couples who bond tighter have higher levels of oxytocin, which is a mammalian hormone that also acts as a neurotransmitter in the brain.[117] One effect of oxytocin is to mediate the spatial tendency, discovered in 1968, that people stand closer to those they like than to those they abhor.[118]

Other examples of common neuronal and hormonal chemicals involved in the process of human bonding included testosterone, estrogen, serotonin, dopamine, norepinephrine, endorphins, and numerous others. The mind is the central processor for these chemicals. The newly developing science of *neurochemistry* is the branch of neuroscience devoted to the study of neurochemicals.[119]

The founding of neurochemistry, as a discipline, traces it origins to a series of *International Neurochemical Symposia*, of which the first symposium volume published in 1954 was titled 'Biochemistry of the Developing Nervous System'.[120] These meetings led to the formation of the International Society for Neurochemistry and the American Society for Neurochemistry. These early gatherings discussed the

tentative nature of possible synaptic transmitter substances such as acetylcholine, histamine, substance P, and serotonin. By 1972, these early discussions and ideas became more concrete and thereafter words, neurochemicals such as norepinephrine, dopamine, and serotonin were classified as 'putative neurotransmitters in certain neuronal tracts in the brain.'[120] In the 1980s, it was also discovered that nerve cells have specific receptor sites for chemicals such as endorphins and that the brain is often awash with hormones sent their from other locations of the body, and in years to follow a flood of research ensued.

The first book to summarize some of these chemical-bonding-love related findings is American psychiatrist Michael Liebowitz's 1983 *The Chemistry of Love,* in which he explored the relation between emotional states, bodily chemistries, and the opiates and amphetamine-like substances produced by the brains of those in love. Others to follow Liebowitz's lead include American sociologist Anthony Walsh with his 1991 *The Science of Love*, American sexual pharmacologist Theresa Crenshaw's 1997 *The Alchemy of Love and Lust,* and the recent 2004 *Why We Love – the Nature and Chemistry of Romantic Love* by American anthropologist Helen Fisher. In addition, scientists and researchers recently have been expanding on these early views by studying how basic mood altering chemicals change in relation to stages of love as can be measured via magnetic resonance imaging scanners.

Neurochemistry

Over the last century, researchers have begun to pry away at the plethora of internal, e.g. biochemicals and neurochemicals, and external, e.g. pheromones, chemicals that operate in relation to the human being. In neuroscience, for instance, magnetic resonance imaging studies have begun to shed light on the neurochemical basis of *human bonding*.[121] Between 1996 and 2001, for example, Helen Fisher, working in coordination with neuroscientist Lucy Brown, research psychologist Arthur Aron, at the state university of New York at Stony Brook, scanned the brains of more than forty men and women who were wildly in love, collecting some one-hundred forty-four scans of brain activity from each.[122] Half of the study participants were in relationships where the love was reciprocated; the rest had recently been rejected by someone they adored. These studies have helped to determine how the circuitry and neurochemistry of the brain in love changes over time.

The list of neurochemicals related to human bonding, to note, is enormous and a topic still in infancy. Here we will only outline the basics.

Main bonding chemicals

- **Oxytocin** [$C_{43}H_{66}N_{12}O_{12}S_2$] – bonding molecule (hormone): high levels correlate with strong pair-bonding; sometimes called the 'cuddle chemical'; levels rise during touching, kissing, and foreplay, and peak during orgasm. Is considered the 'hormone of love'.[123] Associated with

male-female attachment.[124] Is made in the hypothalamus, ovaries, and testes.[122] Is released in women during the birthing process.[125] Initiates contractions of the uterus, stimulates the mammary glands to produce milk, and stimulated bonding between a mother and her infant.[126] At orgasm, levels increase dramatically in women.[126] Released during stimulation of the genitals and nipples.[127] Is secreted in response to the crying of the infant.[11] Thinking about a loved one will cause levels to rise.[128] It reduces stress.[128] It makes people forgetful and diminishes the capacity to think and reason.[128] Is secreted in the posterior lobe of the pituitary gland.[128] When given to females around ovulation, it heightens their efforts to contact males and intensifies lordosis, i.e. sexual presenting.[128] When given to males, they will develop maternal behaviors and infant guard ferociously; when levels are artificially blocked in males, they will neglect their infants and may even eat them.[128] Improves erection, speeds ejaculation, enhances contractions of penile tissue, and increases ejaculation volume and sperm count; conversely, lowered levels reduces sperm count.[128] Penis-vaginal contact and penetration increases levels in both sexes.[128]

- **Vasopressin** – monogamy molecule (hormone); responsible for creating intense loving memories during passionate situations; responsible for clarity of thought and alertness during passionate situations. Associated with male-female attachment.[122] Ejaculation increases levels of in the brain, triggering spousal and parenting zeal.[129] When injected into the brain it causes males to engage in territorial defense behaviors from other males and to become extremely possessive of the female[s] in his territory.[130] When the production of in the brain is artificially blocked, males will copulate with a female and then abandon her for another mating opportunity.[130] Is made in the hypothalamus, ovaries, and testes.[122] At orgasm, levels increase dramatically in men.[131] Released during stimulation of the genitals and nipples.[127] Works with testosterone, modulating male sexual behavior, keeping it from reaching extremes or becoming too hot, i.e. it has a tempering influence.[128] It turns a person's attention from the abstract to the concrete, away from the past and future to the here and now, and appears to improve memory, cognitive powers, and concentration.[128] Secreted from the posterior pituitary gland.[128] It increases attention and alertness while reducing emotionalism.[128] A deficiency of causes a reduction of REM sleep.[412] Artificially increased levels of induces flank-marking behaviors, thus communicating status and instilling dominant-subordinate heirarchies.[128]

- **Endorphin** (endogenous opioid) - calming natural pain killer; levels increase in response to touch, pleasing visual stimulus (as a smile), or after dwelling on positive thoughts.[128] Thought to be the main attachment chemical in long-term relationships.[132] Is associated with love.[126] Exercise elevates levels of some of the endorphins, instilling a calming effect.[122] Stroking and massage trigger the production of, which causes a person to relax, and produces feelings of attachment.[133] Reduces separation-induced crying.[134] Secreted in situations of social comfort and produce a sense of well-being.[134] When people feel socially cut off the brain's production of decreases, which makes people feel anxious and even panicky.[134] When deprived of an

important social bond our levels shut down; with the passage of time, however, the system begins to prime itself again as receptors become more sensitive and storage pools increase their stock.[134] Dwelling on positive thoughts can raise levels of.[128]

Related bonding chemicals

- **Dopamine** [$C_8H_{11}NO_2$] – desire molecule (neurotransmitter): levels increase as passion levels increase; elevated levels are associated with romantic love.[135] Is produced by specialized nerve cells located in the *arcuate nucleus* of the brain. Increased levels associated with sexual arousal and heightened motivation.[136] Elevated levels directly associated with a *preference* for a particular mate.[137] Mate favoritism is associated with a fifty percent increase in the nucleus accumbens, a part of the brain associated with craving and addiction.[138] Reduced levels correlated to indiscriminate mate selection.[139] Injected increases of cause females to prefer the male present at the time of the infusion, even if she had never mated with this individual.[139] Levels spike as an estrus female looks at slides of a males face.[140] Heightened levels associated with extremely focused attention.[141] Heightened levels associated with unwavering motivation and goal-directed behaviors.[142] All major addictions are associated with elevated levels of.[143] Specific brain cells produce greater amounts when a reward is delayed, thus energizing, focusing, and driving the pursuer harder.[144] All basic drives, and particularly sexual drive or motivation, are associated with elevated levels of.[145] Stimulates the release of testosterone.[146] Elevated levels are related to sexual arousal, frequency of intercourse, and positive sexual function.[147] When injected into the blood stream it stimulates copulatory behaviors.[148] When a male is near an estrous female, such that he can see or smell her, his levels rise.[149] During copulation levels rise.[150] Stimulates lust and erectile function.[151] Drugs that elevate levels of in the brain cause sex drive to improve.[152] Very high levels of are associated with intense motivation and goal-directed behaviors, as well as with anxiety and fear.[133] Vigorous exercise drives up levels of dopamine in the nucleus accumbens, bestowing feelings of euphoria.[153] Twice as many receptors for dopamine are found in the limbic systems of schizophrenics.[154] Is responsible for the desire or pursuit of any pleasure; without it, a person will feel no joy, anticipation, enthusiasm, excitement, or exuberance.[128] It is the common denominator of most addictions, such as cocaine and alcohol, and may be with addicts people to each other.[128] It is the neurotransmitter that moves people, drives them to go after what they want, reinforces that desire, and promotes the anticipation of pleasure.[128] Is what makes a person smile as well as induces spontaneous activity and movement.[128]

- **Serotonin** [$C_{10}H_{12}N_2O$] – stability molecule (neurotransmitter). Selective serotonin reuptake inhibitors, such as Prozac or Zoloft, work to elevate levels of and thus alleviate aberrant behaviors such as obsessive-compulsive disorders.[155] During the first six months of love, serotonin levels drop to forty percent below those in normal subjects.[156] Low levels are attributed to a lover's persistent, involuntary, irresistible ruminations, e.g. up to ninety percent of one's waking hours, about a loved one.[157] Both those newly in love within the previous six

months and those will obsessive-compulsive disorder have lower levels of.[158] Rising levels of dopamine and norepinephrine cause levels to plummet.[159] Exercise elevates serotonin.[122] Women taking SSRI's, i.e. serotonin boosters, rate male faces as less attractive than compared to non-medicated women and spend less time looking at the faces.[122] Serotonin enhancer drugs dampen the sex drive and tends to inhibit the sex response.[122] High levels cool one's sex-drive; low levels intensify it.[128] High levels instill a peaceful nature in a person, reduce sex drive, and delay orgasm.[128] High levels promote selectivity in mates, namely same species and heterosexual choice; low levels promote indiscriminate sexual choice of partner and gender.[128] Those with low levels will tend to participate in group sex, in a violent and often frenzied nature.[128] Low levels promotes responsiveness; in females, orgasms come more quickly; in males, ejaculations come quicker.[128] Levels decrease with dieting often added to the sex drive as body image improves.[128] Lower levels of in females will cause them to mount other females and smaller males and behave more like males.[128]

- **Norepinephrine** [$C_8H_{11}NO_3$] - elevated levels are associated with romantic love.[135] Is a precursor of epinephrine (adrenaline) in its major biosynthetic pathway.[160] Increased levels associated with sexual arousal and heightened motivation.[161] The smell of male urine causes levels to increase in the female brain.[162] Levels spike as an estrus female looks at slides of a male's face.[140] Heightened levels associated with lordosis.[163] Increasing levels produce exhilaration, excessive energy, sleeplessness, and loss of appetite.[122] Is associated with increased memory for new stimuli, especially social memory.[164]

- **Testosterone** [$C_{19}H_{28}O_2$] – masculinization hormone (high testosterone-laden males tend to bond with high estrogen-laden females); levels drop in men who are involved in long-term monogamous relationships; functions as the main sex drive hormone for both men and women.[135] It is the hormone of sexual desire and associated with lust in both men and women.[122] Men and women who have higher circulating levels of engage in more sexual activity.[165] Male athletes who inject themselves with it tend to have more sexual thoughts, more morning erections, more sexual encounters, and more orgasms.[122] Women who take supplement of in middle age boost their sexual desire.[165] Women feel more sexual desire around ovulation, when levels increase.[166] When males see a sexually available female or watch a companion copulate with a female, their levels soar.[167] Increased levels of works to elevate levels of dopamine and norepinephrine but to suppress levels of serotonin.[122] Men with high levels of marry less frequently, have more adulterous affairs, commit more spousal abuse, and divorce more often.[122] As a man's marriage becomes less stable, his levels rise and with divorce his levels rise futher.[122] Single men tend to have higher levels than married men.[168] As a man becomes more and more attached to his family, levels decline.[169] At the birth of child, expectant fathers experience a significant decline in levels of.[169] When a man holds a baby his levels decrease.[122] Increasing levels of can sometimes drive down levels of vasopressin (and oxytocin) and elevated levels of vasopressin can decrease levels of.[170] High levels of reduce attachment.[122] High levels of inhibit nurturing behavior in both males and

females.[171] Lowers the firing threshold of the amygdala, the area of the brain most involved with violence and agression.[172] Is responsible for the aggressive sex drive, makes one want to pursue sex, initiate, and dominate.[128] It stimulates desire directly by enhancing levels of dopamine, a neurotransmitter known to increase sex drive.[128] Without testosterone males won't mark their territory or confront intruders; with it, they fight to protect their turf, take ownership of their mates, and often wish to be aloof or alone.[128] Is a potential aphrodisiac for both males and females, promoting the drive for genital sex and orgasm.[128] Promotes masturbation, one-night stands, and a decreased desire for emotional entanglements.[128] It doubles as an anti-depressant, but makes people irritable when it spikes.[128] Levels drop in men who live together.[128] Is extremely sensitive to environmental stimuli, e.g. a confrontation, competition, stress, or the presence of other men or women.[128] Higher levels of in the male increases the attractiveness of the male odors to the female.[128] Levels rise in those who are victorious in combat.[128] Men with high levels of are less likely to get married and more likely to have affairs if they do marry.[128]

- **Estrogen** – feminization hormone (high estrogen-laden females tend to bond with high testosterone-laden males). Attractiveness to men is enhanced by it.[128] It governs the female receptive sex drive and makes a female acquiescent to a man moved to pursue her by testosterone.[128] Generates attractive body odor and texture.[128] Promotes vaginal lubrication and promotes lordosis.[128] In regards to behavior, it prevents depression, reduces stress, improves sense of taste and smell, and decreases appetite.[128]

- **Epinephrine** (adrenaline) [$C_9H_{13}NO_3$] – a basic sympathomimetic stimulate hormone, e.g. it causes a person's heart to race.[160] A mixture of danger, fear, and adventure, e.g. riding on a roller coaster or walking on high creaky suspension bridge, stimulates levels of and new couples are more likely to attach to each other following dates where levels were high.[173] Makes a person more happy in a pleasant situation, but more angry in a frustrating one.[134]

- **PEA** [$C_8H_{11}N$] – amphetamine-like molecule (neurotransmitter) often known as the 'molecule of love.'[128] It speeds up the flow of information between nerve cells.[132] Keeps one alert, confident, and ready to try something new.[132] Causes people to feel optimistic of the future, sleep less, and be more socially out-going.[134] Low levels have been correlated with love-sickness.[122] Is considered the visual component of the chemistry of love, in that its levels surge in the sight of someone desirable or even a picture, art, or something one reads.[128] Levels are typically higher in women, particularly at ovulation, than in men.[128] Levels are high in schizophrenics and during a divorce.[128]

- **DHEA** [$C_{19}H_{28}O_2$] – most abundant hormone in the body; increases sex drive and influences who one finds attractive; levels increase to three to five times that of baseline before and during orgasm. Because most of the other sex hormones are derived from it, it thus unconsciously tells a person when they can or cannot have sex.[128] Pheromones are

derived from it.[128] Responds directly to both emotional and environmental stimuli and drops drastically under stress.[128] Through the action of pheromones, it acts on the brain to influence our choice of mates.[128] Lean females have double the amount of it than obese females.[128] It excites the septum and medial preoptic areas, which are known to promote active and pleasurable sexual behavior and reactions.[128] When males are exposed to the scent of receptive females for seven days, levels are increased in the amygdala and hypothalamus.[128] Vigorous exercise, for about thirty minutes per day, for one month, causes a measurable increase in levels of.[128]

- **Brain-Derived Neurotropic Factor** [BDNF] – exercise increases levels of in the hippocampus, the memory center, which protects and makes new nerve cells.[122] Exposure to stress and the stress hormone corticosterone has been shown to decrease the gene expression of, and leads to an eventual atrophy of the hippocampus if exposure is persistent.[174]

- **Monoamine oxidase** (MAO) – one of the most important brain enzymes involved in the regulation of emotions and is a major metabolizer of norepinephrine, dopamine, serotonin, and PEA.[134] Men with lower levels of tend be sensation-seekers, with a preference for wild or disinhibited forms of behavior and a particular distaste for anything that smacks of routine or is tedious or boring.[134] Those with lower levels are often more social, more active, more playful, and sleep less.[134] People with low levels of seem to have, and to prefer, more intense emotional stimulation in their lives.[134] Schizophrenics have lower levels in their blood.[175] Is an enzyme that removes a variety of neurotransmitters by oxidation after they have performed their task; a deficiency in MAO would leave excess neurotransmitters at the synapses transmitting information which, in reality, not there.[11]

- **Gamma-aminobutyric acid** (GABA) – plays and inhibitory role in the brain.[11] GABA receptors induce calm by inhibiting or modulating over-reactive neurons.[11] Substances such as alcohol and valium have a potentiating effect on GABA synapses, thus instilling a state of calmness.[11]

- **Prolactin** – motherly hormone (stops female and male sex-drive). Is secreted by the pituitary gland and stimulates the growth of mammary tissue and triggers the production of milk.[128] When a baby suckles, levels sore to ten times their normal level.[128] Women who suckle their infants on a regular basis have a severely reduced sex drive.[128] Men with prolactin-producing pituitary tumors often lose their libido completely along with their erections.[128] Dopamine inhibits prolactin, consequently boosting sex drive indirectly.[128] Estrogen gradually increase prolactin secretion, thus diminishing he aggressive sex drive.[128] In both men and women, prolactin secretion is increased by exercise, psychological stress, stimulation of the nipples, and sleep.[128]

- **Cortisol** - the primary hormone product of the adrenal glands; helps restore homeostasis after a state of stress; heightened levels are associated with those newly in love and with the establishment of new relationships.[176] Depressed people have elevated levels beyond what can be explained by the stress they are under.[134] The scent of androstadienone, a volatile component of male sweat, causes levels to rise in females.[177]

- **Progesterone** [$C_{21}H_{30}O_2$] – reverse sex-drive hormone; one of the two female sex hormones along with estradiol that during pregnancy begin to rise causing an intensification of a women's natural femaleness, where she becomes more mothering and nurturing, and while at the same time dampening sexual receptiveness.[11] The rapid decrease in progesterone and estradiol after childbirth is accompanied by increased prolactin and oxytocin, which are themselves stimulated to production by the nursing infant's suckling at it's mothers' breast.[11] Hormonal treatment of induces maternal behavior towards infants, even those not the mothers.[178] It reduces sex drive, by lowering testosterone levels in both sexes.[128] It decreases positive sexual scents, e.g. pheromones, and may make people smell bad to each other, reducing the likelihood of attraction.[128] It makes women irritable towards men and aggressive in protecting their young.[128] Has a mild sedative, anesthetic, and calming effect.[128]

- **Estradiol** [$C_{18}H_{24}O_2$] – reverse sex-drive hormone; one of the two female sex hormones along with progesterone that during pregnancy begin to rise causing an intensification of a women's natural femaleness, where she becomes more mothering and nurturing, while at the same time dampening sexual receptiveness.[11] The rapid decrease in progesterone and estradiol after childbirth is accompanied by increased prolactin and oxytocin, which are themselves stimulated to production by the nursing infant's suckling at it's mothers' breast.[11] Hormonal treatment of induces maternal behavior towards infants, even those not the mothers.[178] Is one of the estrogens that drives the development of secondary sex characteristics in women.[179] Promotes maternal behavior by lowering the threshold for the firing nerve fibers in the *media preoptic area*, an area essential to maternal behavior.[180]

- **Nerve growth factor** – a neuroprotein that stimulates cell growth; higher levels are found with those newly in love as compared to those single or in long-term relationships.[181]

- **Gonadotropin-releasing hormone** (GNRH) – is a pulsatile, rhythmic-release sexual stimulant that reliably increases mating and sexual behavior, e.g. male copulation and female lordosis.[128] Heightened levels in males induces them to spend more time near females sniffing, licking, nuzzling, and nipping.[128]

Neuroanatomy and love

- **Amygdala** – when a person begins to realize that an expected reward is in jeopardy, even unattainable, this area together with centers in the prefrontal cortex trigger rage.[133] The area of the brain most involved with violence and agression.[172] Removal of in violent criminals

results in the elimination of the violent behavior.[11] Levels of DHEA increase in the area when males are exposed to the scent of receptive females for seven days.[128]

- **Limbic system** – first system in the brain to switch on when we see someone attractive.[134] Is considered to be the central location of the 'pleasure center'.[182] Is the central brain region involved in romance.[134]

- **Caudate nucleus** – parts of the body and tail of the *right* caudate nucleus become more active when madly in love and when gazing at a photo of a lover.[122] Associated with detection and perception of a reward, discrimination between rewards, preference toward a particular reward, and anticipation of a reward.[122] Associated with the acts of paying attention and learning.[183]

- **Hypothalamus** – synthesizes and secretes neurohormones, often called *releasing hormones,* as needed that control the secretion of hormones from the anterior pituitary gland. Among other hormones, it releases gonadotropin-releasing hormone (GnRH). The neurons that secrete GnRH are linked to the limbic system, which is primarily involved in the control of emotions and sexual activity.[184] Levels of DHEA increase in the area when males are exposed to the scent of receptive females for seven days.[128]

- **Septum pellucidum** – becomes active when people eat chocolate or when ruminating on an immortal beloved.[185] Some refer to it as the pleasure center.[11] DHEA excites this area and promotes active and pleasurable sexual behavior and reactions.[128]

- **Septum** – the part of the limbic system that regulates emotions and the ability to learn and control impulses as well as such drives as sex, hunger, thirst, aggression, and fear.[186] The septum, or *septal nuclei*, in the brain, named for its approximate shape (partition), receives reciprocal connections from the hippocampus, amygdala, hypothalamus, midbrain, habenula, cingulate gyrus, and thalamus.[187] Is rich with nicotonic cholinergic receptors. Is the area of the brain where orgasmic activity is generated.[128] When stimulated with electrodes, it causes ecstatic reactions resembling orgasms.[128]

- **Ventral tegmental area** – parts of the *right* ventral tegmental area become more active when madly in love and when gazing at a photo of a lover.[122] Is a central part of the reward circuitry of the brain.[188] Is the mother lode for dopamine-making cells.[122] Its tentacle-like axons distribute dopamine to many parts of the brain, including the caudate nucleus.[189]

- **Anterior cingulate cortex** – becomes active, for those 2.3 years in love, when gazing at a photo of a lover.[190] Is where emotions, attention, and working memory interact.[191] Is where a person registers 'butterflies' in the stomach and where the mind processes emotions.[122]

- **Insular cortex** – becomes active, for those 2.3 years in love, when gazing at a photo of a lover.[190]

- **Basal ganglia** – becomes active when gazing at a photo of a lover.[156]

- **Posterior cingulate gyrus** – becomes *less* active when gazing at a photo of a lover.[156]

- **Right pre-frontal cortex** – becomes *less* active when gazing at a photo of a lover.[156]

- **Frontal lobes** – the number of gray cells here is significantly linked to intelligence.[192]

- **Pineal gland** – sunlight is a tonic for depression, i.e. it stimulates this gland, which regulates bodily rhythms in ways that often elevates mood.[193]

- **Locus ceruleus** – region heavily involved in producing terrifying panic attacks and possibly the anxiety felt when separated from love ones.[138]

- **Myelin sheath** – those who are petted, messaged, and loved are found to have significantly more of the material necessary for myelin formation.[11]

- **Cerebellum** – may be involved in developing the human ability to love.[194] Plays an important role in the integration of sensory perception and motor output.[195] Is intimately connected to the *limbic system*, the brains emotional control system, and activation of these two systems, e.g. during sport or play, is the reason for the feeling of exhilaration.[11] A lack thereof, especially for infants, results in somatosensory deprivation, and an inadequate wiring of the pathways between these the cerebellum-limbic system.[196]

- **Medial preoptic area** – an area that is essential to maternal behavior.[180] DHEA excites this area and promotes active and pleasurable sexual behavior and reactions.[128]

- **Vomeronasal organ** (VMO) – a small region in the nasal cavity that is believed to be the organ through which human pheromones act.[197]

Related facts

- **Major histocompatibility complex** (MCH) – is a large genomic region or gene family that plays an important role in the immune system, autoimmunity, and reproductive success, i.e. women are found to be vomeronasally-attracted to men with a more dissimilar complex.[198] Proteins encoded by it are expressed on the surface of cells and display *antigens*, i.e. fragments of molecules from invading microbes or dysfunctional cells, such as tumor cells, to a particular type of white blood cell called a *T cell* that has the capacity to kill or co-ordinate the killing of the microbe, infected cell, or malfunctioning cell.[198]

- **Pheromones** – are sexual signals transmitted from one individual to another through scent, i.e. 'smell-prints', which are derived from DHEA.[128] Convey information about what species type and genotype, the general purpose of which is to transmit information about immune system, a mechanism to avoid inbreeding. Females are attracted to males with the least similar genotype, which means they are attracted to males who are the least likely to be related to them.[199] Are believed to be the chemo-transmission agent involved in the *McClintock effect*, where females that live together will tend to regulate their menstrual cycles in unison following the lead of the alpha female.[200] Male pheromones tend to regulate, synchronize, and to bring female ovulation cycles into a normal range.[201]

- **Androstadienone** – is a volatile chemical compounds that has been described as having pheromone-like activities in humans and is a derivative of the sex-hormone testosterone.[177] It is a component of male sweat that acts as a chemosignal to women causing their levels of cortisol to rise.[177]

- **Androsterone** [$C_{19}H_{30}O_2$] – is a is a steroid hormone with weak *androgenic activity*, i.e. it weakly stimulates or controls the development and maintenance of masculine characteristics and acts as a female pheromone attractor.[128] The consumption of large amounts of celery can cause an increase in the production of this hormone in males.[202] Some musks, such as *Jovan*, contains alpha-androsterone.

- **Seminal fluid** – alleviates depressive symptoms in women.[203]

- **Pleasure center** – stable long-term couples mutually stimulate each other centers in a synergistic manner, conversely un-stable partners have unbalanced pleasure center connections.[204] Inadequate wiring to this center during infancy results in a later inability to fully experience love and pleasure.[11]

- **Alcohol** – a social lubricant.[134] It relives anxiety thus allowing the pleasure center to react more freely.[134]

- **Follicle-stimulating hormone** – males in love have decreased levels of.[176] In men, it enhances the production of androgen-binding protein by the Sertoli cells of the testes and is critical for spermatogenesis.

- **Tactile stimulation** – minimal levels of tactile stimuli deprivation during the stage of active cell growth in infancy results in reduced neural metabolism, reduced dendritic growth, and atrophy of neuron-nourishing glial cells.[205]

- **Midcycle** – the period of ovulation, during which testosterone, increasing the female sex drive, and estrogen, increasing her femaleness, levels both spike.[128]

- **Paramenstruum period** – begins about three days prior to the onset of menstruation and lasts about four days into menstruation. It is estimated that approximately sixty-two percent of violent crimes committed by women are committed in this period.[11] In this period, estradiol levels fall to fifty percent of baseline, while testosterone remains relatively high at eighty-two percent of baseline.[11]

- **Squalene** [$C_{30}H_50$] – a pheromone repellant; stops male courtship behavior in snakes.[128]

The number and extent to which internal body chemicals and neurochemicals effect and function to regulate the process of the formation and dissolution of the human chemical bond will invariably increase in the years to come. Correlating exacting *neuro-*, *bio-*, *pheromonal-* and *hormonal*-chemicals, etc., to term specific emotions and behaviors is a complicated area of research. We should expect many good things to come from these lines of research in the future.

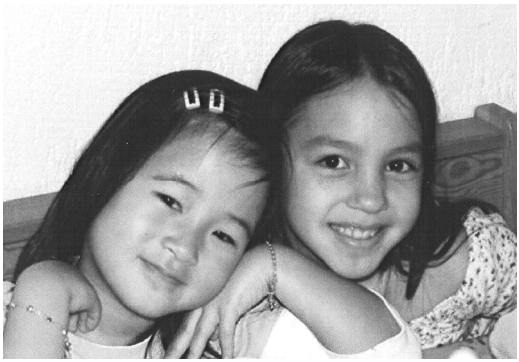
In the following chapter, we will build on this bond history and neurochemical foundation by introducing a rigorous theory of human chemical bonding.

13 – Human Chemical Bonding:

"But what is it all about? People loose and at the same time caught. Caught and loose. All these people and you don't know what joins them up. There's bound to be some sort of reason and connection. Yet somehow I can't seem to name it."

Carson McCullers, The Member of the Wedding[1]

The term *human bond*, or more generally 'human bonding', refers to the process or formation of a close personal relationship, as between a parent and child, especially through frequent or constant association.[2] When pairs have favorable bonds, the nature of this bonding is usually attributed to 'good' interpersonal chemistry.[3] The word *bond* derives from the 12th century Middle English word 'band', meaning something that binds, ties, or restrains. Its application to interpersonal human relationships has been used intermittently ever since. The *friendship bond* is a good example: recent studies have found a direct correlation between happiness and a person's friendship or social bond count.[4]



Friendship Bond

The term *social network* or 'interconnected group of people', which may include up to 150 people, i.e. Dunbar's number, is from 1947.[5] In sociology, a social network is a social structure made of nodes, which are generally individuals or organizations, that are tied by one or more specific types of relations, such as financial exchange, friendship, hate, trade, web links, or airline routes, etc.[6] The concept of a *nuclear family* or bonded unit of two parents plus one or more children was coined by American anthropologist George Murdock in his 1949 work *Social Structure*.[7] The

application of the term 'bonding' to interpersonal relationships came of use in 1976 following the early 1970s publications of psychiatric social workers James and Joyce Robertson who used the term 'bonding' for parent-to-infant attachment.[2] With the recent popularity of the Internet, sites such as *myspace.com*, one of the top-ten most active websites in the world, encourage people to increase the size of their friendship networks.[8] Similarly, the networking site *facebook.com*, a top-twenty site, is self-defined as 'a social utility that connects you with the people around you' and that it is 'made up of many networks, each based around a workplace, region, high school or college'.[9]

Along these lines, people create their lives within a web of vibrant connection to others that operates in the form of a force. This connective force can be quantified in terms of a psychobiology of love and hate.[10] The basic psychobiology perspective, describes the workings of our ancient, pivotal urge for intimacy, revealing that our nervous systems are not self-contained: from earliest childhood our brains actually link with those of the people close to us in a silent rhythm that makes up the life of the body.[11] The cast of linked characters in a life and the nuances to interconnection provide the richness, the intricacy, the abrasion, and much of the interest in living. Life unfolds as a kaleidoscope or relationships, with varying pieces in shifting arrangements.[1]

These relations, connections, networks, ties, unions, marriages, links, etc., as we will explain, are *human chemical bonds*, pure and simple.[12] In the past sixty years, a number of fields, including developmental, abnormal, and evolutionary psychology, anthropology, sociology, physics, and neurology, to name a few, have begun to study the nature of these connections.[13] Yet, writers and theorists who have taken up this challenge have been stymied by the lack of needed language to describe these variations of human bonding phenomena.[14] In short, the nature of the relationship has remained enshrouded partly because, in the words of human bonding theorist and psychologist Ruthellen Josselson, 'we have so few words and agreed-upon concepts to indicated the ways in which people connect themselves to others.'[1]

Typically when speaking of human ties or bonds, chemical analogies are used. The theoretical basis behind these terms, however, usually lack in scientific rigor, particularly in regards to the quantum mechanical nature of bonding. In 1775, for example, Anglo-Irish statesman, author, political theorist Edmund Burke stated in his *Speech on Conciliation with America*, in reference to human bonds, that 'these ties which, though light as air, are as strong as links of iron.' This, of course, is a metaphor. The links of iron are called *metallic bonds*, in which the atoms are considered to be ionized, with the positive ions occupying lattice positions; the valence electrons are able to more freely, or almost freely, through the lattice, such that the bonding force is the electrostatic attraction between the positive metal ions and the electrons.[15] The links that hold human molecules together are not, however,

metallic bonds; although it is still the same force, namely the electromagnetic force, as we will discuss.[16]

Another subtle issue is the entwined relation between love, bonds, and hatred. The word love, throughout history, has always been source of mystery. In the words of the American, German-born, psychoanalyst Erich Fromm, 'there is hardly any word which is more ambiguous and confused than the word love.' In colloquial use, according to 2004 polled opinion, the most favored definitions of *love* involve life, selflessness, friendship, union, family, and bonding or connecting with another. In more detail, shown below, in ranked descending order of preference, are the top ten, out of one-hundred-and-fifty, of the world's most-favored definitions of love:[17]

What is Love?
Someone you'd give your **LIFE** for
To care about a person more than you **CARE** about yourself
Someone you **CARE** about more than anything
FRIENDSHIP
The perfect **UNION** of two souls
FAMILY
Patience & Understanding
Someone who can make you laugh on your worst day
When you can't live without the other person
Unconditional mutual acceptance

Similarly, according to Fromm, 'true' love has five basic elements: *life*, *care*, responsibility, respect, and knowledge. Moreover, Fromm's top definition of love is 'interpersonal *union* in which individuality and personal integrity are preserved.'[18] Fromm intuitively hits upon three of the world's favored love definitions. Fromm states, that to love a person productively, i.e. efficiently, implies to care and to feel responsible for his or her life, not only for his or her physical existence but for the growth and development of all his or her powers. Regarding knowledge, we must know the person to respect him or her and to be aware of his or her individuality and uniqueness. Knowledge of the other person, in Fromm's view, secures power, and power by definition signifies the ability to attract, thus characterizing a quality bond.

Likewise, hatred, the often overlooked but decisive component in bonding, is of significance. In healthy human bonds, a 5-to-1 ratio of attraction to repulsion, i.e. the Gottman stability ratio, will function as a necessary balancing ratio to drive the successful dynamic evolution of the relationship.[19] In other words, repulsors in the form of sour faces, turn-offs, or negative reactions to mate stimuli, are key decisive factors in bond stability. All bonds will have repulsion in them; where there is too much repulsion in the form of pure hatred, no bonds will form.

To elaborate, the real determinants of mate paring, according to American mate behavior psychologist David Klimek, from his 1979 book *Beneath Mate Selection: the Unconscious Motives in Human Pairing*, are unconscious determinants related to individual psychodynamic characteristics. Partner selection, subsequently, and the human bonds resulting therefrom, according to Klimek, revolve around 'an intricate network of human needs attempting to be mutually satisfied by the unconscious needs and conscious desires of each partner.' When a pair decides to bond-commit themselves to each other, in Klimek's view, 'there is no doubt that each needs what the other has to offer.' Yet, as the 'real determinants of pairing are unconscious', as Klimek argues, reactants are thus encouraged to take special notice, in their lives, of the interactions that 'stimulate an emotional reaction, particularly a negative, angry, or nervous reaction.' According to this dynamic logic, negative reactions are often the decisive determinants in configuring bond stability; a 5-to-1 dynamic balance of positive-to-negative reactions, i.e. love-to-hate interactions, will characterize a long-term stable bond, yet too many (or too powerful) negative reactions, i.e. turn-offs, dislike, revulsion, or pure hatred will actuate to break the bond. Repulsion, however, is thus a necessary dynamic of bond stability.

Another to have written in depth about human love and its interrelationship to force, bonding, energy, and power is American psychiatrist Smiley Blanton.[20] In his 1955 book *Love or Perish* Blanton defines love as 'the great combining *force* that seeks to join all parts together. It is the *power* that reaches out to build and construct. Love is the immortal flow of *energy* that nourishes, extends, and preserves.'[21] Likewise, according to child development philosopher and human thermodynamicist Elizabeth Dole, who studied Blanton's work, his definition of love describes the relation in which two or more human beings unite to follow the creative impulse inherent in life to join, arrange, harmonize, and unify.[22] Where, as she states, 'as long as the sexual union takes place because of the impulses of both partners, it is marvelous.' Here, we find direct connections between love, power, psychology, bonding, energy, and force.

These descriptions are all very clear, yet when it comes to describing the *force* of love in human bonding, in terms of the four fundamental forces of the universe, the picture becomes more complicated:[23]

Fundamental Force	Relative Strength	Carrier Name	Symbol	Range (fm)	Mass (MeV/c^2)
Strong Force	1	Gluon	g	2	0?
Electromagnetic Force	10^{-3}	photon	γ^0	∞	0
Weak Force	10^{-16}	Intermediate Vector Boson	$W^{\pm}$, Z^0	10^{-3}	10^5
Gravitational Force	10^{-41}	Graviton	g^0	∞	0

The bulk force of love, as we will discuss, is the electromagnetic force, however, the gravitational force has an elusive yet indirect relation to the dynamics of love, e.g. the female menstrual cycle, and the sensual attractions and repulsions it mediates, is regulated by the force of gravitation. To clarify, in a way that avoids recourse to the word love, the world's top definition of love is someone (or something) one would give his or her life for. Life, as we have explained, is a chemical reaction and the meaning of life is to react. Hence, love, and the relevant aspects of hate involved, is a reaction or set of reactions to which one would give their life to. The force behind all chemical reactions is the electromagnetic force.[26] Subsequently, the force of love or hate is the electromagnetic force. In modern terms, forces are more appropriately thought of in terms of interactions in which the exchange of field particles transmits the force:

> **Exchange force** – a force whose apparent character lies in the assumption of a continuous exchange of particles, which accompanies the interaction and transmits the force, resulting from the continued interaction of particles in a manner that bonds their hosts together.[26]

To compound this force issue further is the entwined yet distant relationship between the electromagnetic force and gravitation, which are distant cousins to each other.[24]

Electromagnetic force

In the universe, there are only four forces, as tabulated above, that are known to operate in the formation of bonds as well as being that responsible for the effects of change.[16] Two of these, gravity and electromagnetism, are familiar in the everyday world because they have a long range. The other two, the strong and weak nuclear interactions, sometimes referred to just as the strong and weak force, have a range roughly comparable to the size of the atomic nucleus. In the 1980s, a hypothetical 'fifth force' was invoked to explain seemingly anomalous results from experiments

to measure the strength of the force of gravity with very high precision. Further experiments showed that there is no fifth force, and that the seemingly anomalous results could all be explained by local variations in the earth's gravitational field caused by differences in the density of near-surface rocks.[16] In sum, if there is an attachment in the universe it is one of the four fundamental forces at work.[25]

The quantum field particle or messenger that carries the electromagnetic force is called the photon, symbolized γ.[26] To elaborate on how the electromagnetic force functions, through the use of energy photons, to drive human reaction life, in 2003, as mentioned, chemistry professor Sason Shaik, from Hebrew University, in his popular essay 'Chemistry – a Central Pillar of Human Culture', defined the human chemical bond as such:[27]

> "The accumulation of chemical knowledge has taught us, however slowly, that behind the spectrum of human traits there lie chemical mechanisms of molecular motions and mutual interactions of molecules with each other and with the surrounding *photonic field*."

To create human bonding dynamics, the photonic field 'interacts' with valence shell electrons of the atoms and molecule that constitute life in such a manner so as to mediate evolution and chemical change. Photon-electron-interactions result to create molecular movements and bonding reconfigurations.

In sum, the electromagnetic force is the force behind human chemical reactions, but as quantum mechanics as shown, technically as Albert Einstein showed in 1905, electromagnetic waves consist of photons, an idea originally expounded on by James Maxwell in 1861 who pointed out that light consists of propagating electromagnetic fields; a fact that he clearly stated in 1864:[28]

> "The agreement of the results seems to show that light and magnetism are affections of the same substance, and that light is an electromagnetic disturbance propagated through the *field* according to electromagnetic laws."

We now know that electromagnetic fields are comprised of photons and that electric and magnetic forces are assumed to be due to the action of photons. The photons of light, however, are different then the photons associated with those such as an electric field around a charged object. The photons of light are described as being 'on the mass shell' whereas the photons of static fields are 'off the mass shell'.[29]

To give an example, one imagines that a point charge source, such as the proton, continuously emits photons that then move out and later return. This is a very quantum mechanical situation; in the conventional view, a photon moving out would

be unstoppable and normally not return. In quantum mechanics, strange processes like this can happen for short times, longer as the energy of the associated photon is less.[31] An electron passing by the proton, for example, might intercept such a photon absorbing its momentum and energy and thus changing course. These processes are explained easily using Feynman diagrams and quantum electrodynamics.[30] This is how we understand, for example, the scattering of an electron in the electric field of a proton. In this view, the concept of a 'force' does not make any sense. Instead, we have 'interactions', e.g. protons or electrons emitting or absorbing photons. What we thought of as a force, in the past, has become the *exchange of a particle*.[31]

To clarify, according to Dutch physicist Martinus Veltman, winner of the 1999 Nobel Prize in Physics for elucidating the quantum structure of electroweak interactions in physics, the 'photon is central to electromagnetic interactions: all interactions classified as electromagnetic do involve a photon.' In human terms, as all human interactions are electromagnetic, they all do involve a photon. Similarly, according to Veltman, 'strong interactions always involve a gluon, weak interactions almost always involve the W or Z particles, and the gravitational interactions always involve a graviton. In this sense, these particles, gluon, photon, W, Z, and graviton, are indeed representative for these interactions.'[32] The strength of these four forces vary as such:

$$F_S > F_E > F_W > F_G$$

To elaborate further, according to American physicist Richard Feynman, one of the main founders of 'quantum electrodynamics' (QED), from his 1985 book *QED – the Strange Theory of Light and Matter*, after Einstein's 1905 light quanta hypothesis, the new science of quantum mechanics was developed which 'supplied the theory behind chemistry'. Hence, according to Feynman, 'fundamental chemistry is really physics'. Feynman explains that because the essential theory of quantum mechanics explained all of chemistry and the various properties of substances, it was a huge success. Yet, according to Feynman, 'there remained the problem of the interaction of light and matter', i.e. technically the interaction of light with outer valence shell electrons. That is, he continues, 'Maxwell's theory of electricity and magnetism had to be changed to be in accord with the new principles of quantum mechanics.'

Hence, in the years following the great quantum works of those as Planck, Einstein, Bohr, de Broglie, Schrödinger, and Heitler, etc., according to Feynman, a new theory, the quantum theory of 'the interaction of light and matter, which is called by the horrible name *quantum electrodynamics*, was finally developed by a number of physicists in 1929.' He continues, 'I would like to again impress you with the vast range of phenomena that the theory of quantum electrodynamics describes', which according to Feynman is easier to say backwards:[33]

> The theory [QED] describes all the phenomenal of the physical world except the gravitational effect.

In a second comment, Feynman notes correctly that quantum electrodynamics does not explain radioactive phenomena, which involve nuclei shifting in their energy levels. Thus, according to Feynman, 'if we leave out gravity and radioactivity (more properly, nuclear physics), what have we got left? Gasoline burning in automobiles, foam and bubbles, the hardness of salt or copper, the stiffness of steel.' In fact, as he states, 'biologists are trying to interpret as much as they can about life in terms of chemistry, and as I already explained, the theory behind chemistry is quantum electrodynamics.' This was the perspective in 1985, according to Feynman, and it has not changed to this day. In the world physics community, Feynman's word is considered textbook fact.[34]

This picture is very clear and absolute. There are four fundamental forces in the universe and the electromagnetic force, in the form of a 'photonic field', is what mediates the act or process of human life. In spite of this great clarity, however, many non-scientists are confounding this elegant picture by publishing non-technical books filled with purported or misinformed theories of hypothetical 'forces of the universe'. Examples include English journalist Lynne McTaggart's 2001 book *The Field – the Quest for the Secret Force of the Universe* (#560), Hungary philosopher Ervin Laszlo's 2004 book *Science and the Akashic Field – an Integral Theory of Everything* (#16,940), and American business consultant Brenda Anderson's 2006 book *Playing the Quantum Field – How Changing Your Choices Can Change Your Life* (#88, 750).[35]

In each of these books, we find an author with non-scientific credentials twisting basic scientific theory around to fit their argument. It is certainly not our intention to author-bash, but the indirect effects and repercussions associated with the spreading of well intentioned, but misinformed conceptions through the bulk minds of common knowledge, are detrimental to the betterment of hard science. To elaborate, quoting from Lavoisier, during the chemical revolutionary years, starting in the 1770s, in regards to his task of having to reinvent the chemical nomenclature by doing away with misuse and misapplication:

> We must clean house thoroughly, for they have made use of an enigmatical language peculiar to themselves, which in general presents one meaning for the adepts and another meaning for the vulgar, and at the same time contains nothing that is rationally intelligible for the one or for the other.

Through the words of Lavoisier then, our objective here will be to 'clean the house' of the various hypothetical force theories currently purported to describe human life. That the mechanisms of human behavior are driven by forces, to note, was a view correctly stated in 1918 by German-born American biological physiologist Jacques Loeb: 'the analysis of the mechanism of voluntary and instinctive actions of animals is based on the assumption that all these motions are determined by internal and external forces.'[161] The explication of these internal and external 'forces' in the language of fundamental forces, however, has not yet been done and great confusion abounds in current publications.

To clarify by example, McTaggart in her book borrows from hard science the physics term 'zero point field' to argue that this is the missing *life force* that guides biology.[36] This is a clear mis-application of basic science. To explain, in 1900, to review a bit, German physicist Max Planck derived the formula for the energy of a single 'energy radiator', i.e. a vibrating atomic unit, as:

$$\varepsilon = \frac{h\nu}{e^{\frac{h\nu}{kT}} - 1} \qquad [13.1]$$

where h is Planck's constant, ν is the frequency, k is Boltzmann's constant, and T is the temperature. In 1913, using this formula as a basis, Albert Einstein and German physicist Otto Stern published a paper of great significance in which they suggested for the first time the existence of a residual energy that all oscillators have at absolute zero. They called this 'residual energy' and then *Nullpunktsenergie* (in German), which later became translated as *zero-point energy*. They carried out an analysis of the specific heat of hydrogen gas at low temperature, and concluded that the data are best represented if the vibrational energy is taken to have the form:[37]

$$\varepsilon = \frac{h\nu}{e^{\frac{h\nu}{kT}} - 1} + \frac{h\nu}{2} \qquad [13.2]$$

Thus, according to [13.2], even at absolute zero, the energy of an atomic system has the value ½ $h\nu$. This energy, in turn, has an associated field, i.e. a zero-poing field.

Connected to his is what is called the 'vacuum state'. In quantum field theory, the *vacuum state* is the quantum state with the lowest possible energy.[38] Hence, in the years to follow Einstein and Stern's publication, the term *zero-point field* began to be used as a synonym for the vacuum state of an individual quantized field.[39] It is a peculiar term, not widely used, but roughly it is the empty quantum field, of which the quantized electromagnetic field would be an example.[40]

Hence, in her book, McTaggart argues that the energy (or field) associated with the vacuum state of an individual quantized field near absolute zero of temperature is the 'secret force of the universe' and that it explains 'human energy fields' according

to rules that seem to 'overthrow the current laws of biochemistry and physics.' Her book is filled with lots of interesting data, but is explained all wrong, e.g. she says 'at our most elemental, we are not a chemical reaction, but an energetic charge.' This is obviously incorrect. In our most elemental, we are 26-element molecules that are thermodynamically-driven through chemical reactions.

Likewise, Anderson, who sites McTaggart as her founding source, along with other fluff-balls, such as Fred Wolf, David Hawkins, and Masaru Emoto, states that people have personal *fields*, which she defines as 'a region of space in which a given effect exists.'[41] She continues 'have you ever noticed how some people feel warm and inviting, while others seem to radiate a kind of stay away energy?' In addition, 'each person's thoughts connect to the field' and that each person is 'not distinct and separate from their environment but are bundles of pulsating energy that constantly interact[s] with this vast energy field.' She calls this a *quantum field* and argues that in the field, we are 'energetically connected to each other, to the results of our choices, and to our futures.' These are all nice descriptions and loosely correct in a verbal sense, but she does not explain the theory behind them correctly. She even runs a business-consulting website called *quantumties.com*, where the motto is 'connecting the world: one transformed, inspired, effective, specialist at a time'. Through her four-step process, supposedly, one can to achieve a 'quantum leap in energy service capacity and bottom-line results'.[42]

In a similar manner, Laszlo uses the Sanskrit word *Akasha*, meaning 'ether': all-pervasive space, originally signifying 'radiation' or brilliance', in Indian philosophy, to argue that a new field is being discovered. He cites American integral thinker Ken Wilber and American quantum physicist David Bohm as his supports and states that 'for thousands of years, mystics and seers, sages and philosophers maintained that there is such a field; in the east they called it the Akashic Field, but the majority of Western scientists considered it a myth.'[43] He continues 'today, at the new horizons opened by the latest scientific discoveries, this field is being rediscovered.' He calls this an 'A-field' stating that it informs all living things, i.e. the entire web of life, and that it informs our consciousness.

In his book, he builds on the concept of the *quantum vacuum* that in quantum field theory is the quantum state with the lowest possible energy, which he defines as 'the zero-point energy field that fills all of cosmic space, and discuses how this field 'could convey not only energy, but also information'.[39] Building on this mis-applied logic, he states that 'an information field underlies all things in the universe' and that his A-field theory is this missing cosmic information field. He declares that this is the foundation of a 'theory that can clarify many of the hitherto puzzling yet fundamental features of quanta, galaxies, organisms, and minds.'

His logic, similar to his new-age 'field' publication associates, is off. In the correct manner, humans are molecules that chemically react on a substrate, reactions that are driven via energy-containing photons emanating from the sun. In addition,

as Feynman has shown, all of chemistry, human chemistry included, is a direct result of the interactions of electromagnetic light with matter, i.e. of photons with outer shell valence electrons, as described by quantum electrodynamics. The picture is very clear: the *field* is comprised of photons and the *actors* are dynamic bound state entities, such as humans, of nuclei and electrons. Everything can be explained via these three components.

In any event, another off force theory is British biologist Rupert Sheldrake's 'morphogenic field', as defined in his well-researched, but poorly theorized, 2003 book *The Sense of Being Starred At.*[44] Sheldrake's *morphogenic field,* is defined as a hypothetical biological, and potentially social, field that contains the information necessary to shape the exact form of a living thing, as part of its epigenetics, i.e. any forms of inheritance that are not simply the direct result of inherited gene collections.[45] This hypothesis is not accepted by most scientists, who consider it pseudoscientific.[46] Sheldrake's data sets, however, are interesting, e.g. he shows, through use of double-blind placebo controlled studies, how talking Parrots can be made to say words that are on a person's mind who is located in a separated room; or how a 'sender' in a separated room of a sleep lab can look at randomized pictures on cards and affect a second person's dreams, i.e. the 'receiver', who is in an adjacent room. His theories of how these thought processes work, however, are illogical.

Sheldrake originally published his ideas in 1973, offering several examples as evidence in support. One was the research English physiologist and instinct theorist William McDougall, who, in the 1920s, studied the abilities of rats to correctly solve mazes. He found that the offspring of rats that had learned the maze were able to run it faster. The first rats would get it wrong 165 times before being able to run it perfectly each time, but after a few generations it was down to 20. McDougall attributed this to some sort of Lamarckian evolutionary process, such as genetic memory. An alternative explanation, however, involved the rats following the scent left behind by their predecessors.[45] Sheldrake attributed this process to his theory of morphogenetic fields. The rats running the maze the first times built their pattern of learning into the 'rat field', and later rats were able to draw on this now-established pattern.

Sheldrake's theory is similar to American quantum physicist David Bohm and American neuroscientist Karl Pribram's *holonomic brain model*, which posits that the brain operates in a manner similar to a hologram, in accordance with quantum mathematical principles and the characteristics of wave patterns.[47] Holography is the science of producing 'holograms'; an advanced form of photography that allows an image to be recorded in three dimensions.[48] The waveforms of the brain, it is argued, may compose hologram-like organizations, Bohm suggested, which could be quantified using Fourier analysis, a mathematical method for decomposing complex waves into component sine waves.[49]

Similar to this hologram model, Sheldrake, in efforts to justify his morphogenic field model, sites evidence from chemistry, in which a yet to be explained learning behavior takes place in the formation of crystals. When a new chemical compound is first created it will crystallize slowly, but when other researchers repeat the experiment they find it occurs more quickly. Chemists hypothesize that this is due to better experiments, i.e. the parts of the first experiment that result in slower growth are documented and not repeated. If this is correct, using documented processes should consistently result in slower crystal growth; however, this hypothesis does not appear to have been tested. Sheldrake also attributed this to a morphogenetic field, suggesting that the crystals being formed for the first time were influencing a field that later crystals drew on.[45]

These types of arguments used by Sheldrake are interesting, but the word he should be using is electromagnetic field, not morphogenic field. To elaborate on his theoretical inconsistencies, according to American mathematician Ralph Abraham, who reviewed Sheldrake's hypothesis, 'the new science of life of Sheldrake tries to restore vitalism to biology.'[50] The historical theory of *vitalism*, i.e. a doctrine that the operational functions of living organisms are due to a vital principle distinct from physicochemical forces, however, was disproved over a hundred years ago.[51]

To sum this discussion up, some of these scientists, such as McTaggart, Bohm, and Sheldrake, etc., are digging around in some interesting topics in their writings, topics such as interrelation between the quantum field and successful people, remote sensing, the holonomic brain model, how dogs can sense when their owners are coming home, how people can intuitively sense when they are being lied to, etc., but the explanations fall short.[52] These are all negligibly statistical topics that are certainly in need of explanation; the difficulty, however, in explaining some of these phenomena correctly in terms of photons, relates to some of the mysteries related to the photons themselves. One is the famous 'double slits' experiment, where when a single photon (or proton, electron, atom, molecule, or buckyball, etc.) is fired at a wall containing two slits, the one photon seemingly goes through both slits.[53] Feynman called this 'the central mystery' of quantum physics.[54] Another puzzle is the phenomenon of quantum *nonlocality* an irregularity pointed out by Irish physicist John Bell in the mid-1960s, where two quantum entities, such as photons, that had once been in contact seem thereafter to remain 'aware' of each other when far apart. In the 1990s, researchers at Geneva confirmed this when they sent photons along fiber-optic cables 6.2 miles in length. The experiments showed that the two photons acted like one particle even when they were more than six miles apart.[54]

In conclusion, the theory of vitalism is no more, but having been replaced by the theory of the elusive photon, which itself still has a few details to work out. In the history of chemistry, the conception of vitalism played a pivotal role, giving rise to the basic distinction between basic organic and inorganic substances, following Aristotle's distinction between the mineral kingdom and the animal and vegetative

kingdoms.[55] The basic premise of these vitalist notions was that organic materials differed from inorganic materials in possessing a *vital force*; accordingly, vitalist theories predicted that organic materials could not be synthesized from inorganic components. As chemical techniques advanced, however, the vital force theories began to fall apart. Specifically, in 1828, German chemist Friedrich Wöhler disproved the vitalist theory when he synthesized organic urea CN_2H_4O from inorganic components.[56] Wöhler subsequently wrote to Swedish chemist Jöns Berzelius, saying that he had witnessed 'the great tragedy of science, the slaying of a beautiful hypothesis by an ugly fact.' The 'beautiful hypothesis' was vitalism; the ugly fact was a dish of urea crystals.[55] In modern terms, the 'vital force' is now known as the electromagnetic force, which can be described in terms of fields of photons.

Historically, the term 'field', in physics, was originally introduced by English chemist and physicist Michael Faraday in the 1830s.[57] During these years, in one particular experiment, Faraday sprinkled iron filings on a paper that was held over a magnet and noticed the filings had arranged themselves along what he called 'lines of force'.[58] The connections along the lines showed where the strength of the field was equal. With the magnetic field now visible, scientists began to wonder if space itself was also filled with interacting fields of various types. Up to this point, most scientists had believed in the mechanical nature of the universe as established by Galileo and Newton. Taking the concept of his *lines of force* one step further, Faraday realized that when an electric current began to flow it caused lines of force to expand outward. When the current stopped, the lines collapsed. If the lines expanded and collapsed across an intervening wire, an electric current would be induced to flow through it, first forward then in reverse.[58]

These early experiments by Faraday led to the development of Maxwell's field equations. Specifically, in 1861, utilizing Faraday's terminology and experimental findings and building on an 1847 paper by William Thomson entitled 'Mechanical Representation of Electric, Magnetic, and Galvanic Force', Scottish physicist James Maxwell published a 62-page paper entitled 'On the Physical Lines of Force'.[59] In the opening sentence, he states 'in all phenomena involving *attractions or repulsions* (such as modeled by [6.3]), or any forces depending on the relative *position of bodies* (such as modeled by [6.11]), we have to determine the magnitude and direction of the force which would act on a given body, if placed in that position.' Here we find Maxwell outlining the rudiments of the phenomenon of human chemical bonding.

Next, he states 'in the case of a body acted on by the gravitation of a sphere, this force is inversely as the square of its distance, and in a straight line to the centre of the sphere. In the case of two attracting spheres, or of a body not spherical, the magnitude and direction of the force vary according to more complicated laws (such as modeled by [6.12]).' He goes on to state that the magnitude and direction of the *resultant force*, in relation to the electric and magnetic phenomena, at any point in

space is the main subject of his investigation. He continues, 'suppose that the direction of the force at any point is known, then, if we draw a line so that in every part of its course it coincides in direction with the force at that point, this line may be called a *line of force*, since it indicates the direction of the force in every part of its course.' These lines of force are what define the three-dimensional structure of the electromagnetic field, being that which comprise the field strength of love and hate, in colloquial human terms.

Thus, according Maxwell, 'by drawing a sufficient number of lines of force, we may indicate the direction of the force in every part of the space in which it acts.' It is in these statements that we find the *force* of the human chemical reaction defined. In the years to follow, Maxwell improved on his theory and later, in 1873, published a fundamental summary of his work in a robust 506-page *Treatise on Electricity and Magnetism*, upon which a large part of modern physics is built.[60]

Maxwell's field equations

The *electromagnetic force*, in a modern sense, is the force that the electromagnetic field exerts on electrically charged particles.[61] Said another way, the bonds that link the constituents of solids, liquids, gases, and plasma are based on quantum photonic interactions as defined by the electromagnetic force.[25] Originally, electricity and magnetism were thought of as two separate forces. The ancient Greeks, for example, had noted that the lodestone attracts small particles such as lint or feathers through some sort of electrostatic force. Likewise, in 400 BC, Chinese writers had noted that 'the lodestone makes iron come or it attracts it.'[62] In 1600, English physician William Gilbert proposed, in his *De Magnete*, that electricity and magnetism, while both capable of causing attraction and repulsion of objects, were distinct effects.[63]

These older views were changed significantly, however, with the publication of Maxwell's 1873 *Treatise on Electricity and Magnetism* in which the interactions of positive and negative charges were clearly shown to be regulated by one force. In the preface section, to this great work, Maxwell tells us 'the fact that certain bodies, after being rubbed, appear to attract other bodies, was known to the ancients. In modern times, a great variety of other phenomena have been observed, and have been found to be related to these phenomena of attraction.' He continues 'they have been classed under the name of *Electric* phenomena, amber *elektron* (Greek), having been the substance in which they were first described.'[64]

To elaborate on the word 'magnetic', Maxwell states 'other bodies, particularly the loadstone, and pieces of iron and steel which have been subjected to certain processes, have also been long known to exhibit phenomena of action at a distance. These phenomena, with others related to them, were found to differ from the electric phenomena, and have been classed under the name of *Magnetic* phenomena, the loadstone, *magnes* (Greek), being found in the Thessalian Magnesia.'[65]

In the years following the turning-point invention of the battery by Italian physicist Alessandro Volta in 1800, four main electro-magnetic effects resulting from electric and magnetic interactions came to be discovered, which have since been clearly demonstrated by experiment. These are:[66]

1. Electric charges attract or repel one another with a force inversely proportional to the square of the distance between them: unlike charges attract, like ones repel.
2. Magnetic poles (or states of polarization at individual points) attract or repel one another in a similar way and always come in pairs: every north pole is yoked to a south pole.
3. An electric current in a wire creates a circular magnetic field around the wire, its direction depending on that of the current.
4. A current is induced in a loop of wire when it is moved towards or away from a magnetic field, or a magnet is moved towards or away from it, the direction of current depending on that of the movement.

These effects are explained by Maxwell's field equations, as developed by Maxwell in the 1860s.[67] Maxwell's equations are a set of differential equations describing the space and time dependence on the electromagnetic field and are the basic equations of classical electrodynamics.[68] *Maxwell's field equations* are:

$$\nabla \cdot \mathrm{D} = \rho \qquad [13.3]$$

$$\nabla \times E = -\frac{\partial B}{\partial t} \qquad [13.4]$$

$$\nabla \cdot \mathrm{B} = 0 \qquad [13.5]$$

$$\nabla \times H = \frac{\partial D}{\partial t} + J \qquad [13.6]$$

where '$\nabla\cdot$' is the *divergence operator*, '∇x' is the *curl operator*, D is the *electric displacement*, E is the *electric field strength*, B is the *magnetic field strength*, ρ is the *volume charge density*, and J is the *electric current density*.[69] This fundamental set of equations encompass Coulomb's law [13.3], Faraday's laws of electromagnetic induction [13.4], Gauss' law for magnetism, i.e. the absence of magnetic monopoles [13.5], and a generalization of Ampère's law [13.6], laws that were originally derived in 1780, 1831, 1835, and 1825, respectively.

Electrical engineers, as an example, use Maxwell's field equations to quantify the transmissions of cellular signals, having a frequency of 10^9 Hz, and radio wave signals, having a frequency of 10^6 Hz, between mobile phones. Signals are picked up and transmitted by the electromagnetic field of the antenna and processed by the phone's microprocessor. In human terms, by comparison, the infamous 'sixth sense', although a very negligible and mostly non-functional sense, compared to the more dominant senses, namely sight, hearing, smell, touch, taste, etc., operates

according the principles embodied in Maxwell's equations. Pets can sense when their owners are coming home; parrots can be made to say words that person in a separated room ruminates on; dogs can sense 20-minutes prior to when their owner is going to have a seizure, animals can sense when they are being hunted; fisherman known that to catch fish they need to clear their mind, e.g. by listen to a game or drink some alcohol, to take their thoughts off the fish; spouses, similarly, can sense when their wives or husbands are cheating on them, even if it is across the world.[70]

Interest in 'seizure dogs', for instance, first came about in the 1980's when the news media picked up on a story that a woman's dog seemed to know when she was going to have a seizure. Since then the public's interest in seizure dogs has grown and created a demand for information, and how to get such a dog.[71] In 1998, to study this claimed phenomena, Roger Reep, an associate professor in the department of physiological sciences at the University of Florida surveyed 77 people between the ages of 30 and 60 who had epilepsy. Most of the people responding had dogs for companionship, 3 out of 31 felt their dogs seemed to know when they were going to have a seizure (10%) while another 28% said their dogs stayed with them when the had a seizure. He concluded that reports should be viewed as credible, but with caution. Similarly, an English study in 1999 reported in the *European Journal of Epilepsy Seizures* in fact showed that they were able to train people and dogs to work together with the results that 'some' dogs could warn of pending seizures through a reward-based conditioning system.[71]

These subtle mental intuitions, although relatively negligible in daily life, can be quantified and explained in a similar manner via Maxwell's field equations. Each thought has specific electromagnetic frequency and associated information content: sleep (0-4 Hz), strong sense of being alive (4-8 Hz), relaxed thoughts (8-12 Hz), mild focus (12-14 Hz), moderate focus (14-16 Hz), intense focus (16-20 Hz), hypervigilant, extreme anxiety, or panic (20-24 Hz), robotic movements or no sense of self or others (24-28 Hz), and no reported feelings; often used as a control for muscle groups (28-31 Hz).[72] In the neuro-structure of the mind, there exist millions of tiny neuro-antennas, e.g. axons and dendrites, which due to alternating current flows have associated tiny electromagnetic fields, each of which can transmit and receive these types of subtle signals, similar a cellular phone.

This is just one simple example; easy to explain, owing to the fact that intuitions in the form of brainwaves do not require the use of complicated intermediates, such as pheromones, hormones, and neurotransmitters, cells, voltage potentials, etc., to mediate the force of the message. For dominant sensor interactions, i.e. sight, smell, touch, taste, and hearing, however, we resort to the use basic quantum field theory, specifically quantum electrodynamics, as defined via force-carrying *primary* and *secondary* field particle messengers, to define all human interactions.[73] In sum, Maxwell's field equations define the basic operation of the electromagnetic force.[74] It is the electromagnetic force, on the four fundamental forces of the universe, that

holds electrons and nuclei together in atoms; atoms together to make molecules; molecules together to make supermolecules, and human molecules together to make relationships and social structures. The electromagnetic force operates via the exchange of messenger particles called photons.[75] The exchange of messenger particles between bodies acts to create the 'perceptual force' whereby instead of just pushing or pulling particles apart, the exchange changes the character of the particles that swap them.[16]

This definition is absolute and very clear. The relationship between bonding, human life, the electromagnetic force, and gravitation, however, is not so clear. This is a major point of confusion in current human knowledge. In general, people agree that the essential bond of human life is a chemical bond.[76] When it comes down to what technically it is exactly that constitutes this human chemical bond, i.e. force, name, composition, mechanism, etc., however, there is blueprint, i.e. no one has ever clearly stating a basic definition of the human chemical bond.[77]

To elaborate a bit, prior to the famed quantum revolution (1897-1927) and the discovery of DNA (1953), many dominant scientists, e.g. German physician Franz Mesmer, with his 1774 'animal magnetism', German chemist Carl Reichenbach, with his 1845 'odic force', or French philosopher Henri Bergson, with his 1907 'Élan vital', etc., believed that the characteristic features of living organisms were manifestations of a 'special force', i.e. vitalism, operating only in living organisms and known variously as *pneuma*, *archeus*, *Lebenskraft*, entelechy, or the 'biotonic laws', etc.[78] A biotonic law, for example, a phrase coined in the 1950s by German physicist Walter Elsasser, is defined as a law of nature which cannot be contained in the laws of physics.[79] There is, however, no such law.[80]

In the late 19th century, similarly, French physiologist Claude Bernard attempted to explain the vital phenomena of nature by distinguishing between 'legislative' and 'executive' forces of living systems.[78] In 1888, to elaborate on current views during these years, French psychologist Alfred Binet, one of the inventors of the Stanford-Binet Intelligence Scale, stated 'the modern opponents of vitalism seek to confute the theory by attempting to explain all phenomena of life from physico-chemical forces. They maintain that according as physiology advances the tendency is to relegate all phenomena nominally physiological into the domain of physics and chemistry; and that it would be only a question of time, if as yet they had not succeeded in demonstrating that every vital process is founded upon the mechanical phenomena.'[81] These opponents, as we see, were correct in their views.

Another popular pseudo-force, is American author William Atkinson's theory of intention and *mental-force*, as promoted in his 1903 book *Thought-Force in Business and Everyday Life*, which is a series of lessons in personal magnetism, psychic influence, thought-force, concentration, will-power, and practical mental science.[82] In short, Atkinson uses the 1655 French term *magnetism* meaning 'personal charm' along with Austrian physician Franz Mesmer's 1829 theory of *mesmerism*, i.e. the

theory of 'animal magnetism' and a mysterious body fluid which allows one person to hypnotize another, to expound on his theory of 'personal magnetism'.

In his book, Atkinson states that there are 'numerous theories which have been advanced to account for the phenomenon of personal magnetism', and that he has 'no pet theory to advance', but that he 'will endeavor to teach you how to obtain *results*, and you can then read up on the subject of theories, or possibly formulate a new theory of your own.' He continues, using a sort of backwards mental-force psychology in his writing, 'I will state briefly my own conception of the cause underlying the phenomena alluded to in this work, but I shall not attempt to force my views upon you.' He goes on, in his short 100-page book, to discuss such terms as adductive quality, telepathic volation, magnetic gaze, and thought absorption, etc., in efforts to prove that personal magnetism exists.

In sum, the idea that certain fascinating human molecules will have higher levels of personal charm, i.e. high charm bond valence, than others is certainly a correct point of view. We all agree that certain people will have higher levels of charm, personal magnetism, and charisma, historically, those such as Cary Grant, Audrey Hepburn, Sophia Loren, etc., than others, but the correct term should be *personal electromagnetism*, thus the conditional terminology that it is the electromagnetic force that directly mediates personal levels of charm.

In 1906, Atkinson expanded on his mental force - personal magnetism theory, in his 88-book *Thought Vibration: the Law of Attraction in the Thought World,* by mixing in Plato's first law of affinity, namely 'like attracts like', to argue that the universe is governed by this one law and that thought is a force, a manifestation of energy, having a magnet-like power of attraction. He states that this one law 'draws to us the things we desire or fear' which in turn either 'makes or mars our lives.'

Similar to this, is American author Wallace Wattles' 1910 book *The Science of Getting Rich*, in which he expounds on Plato's first law of affinity to argue that the 'science of getting rich is an exact science, like algebra or arithmetic' and that there are 'certain laws which govern the process of acquiring riches; once these laws are learned and obeyed by any man, he will get rich with mathematical certainty.' He states Plato's law as such 'it is a natural law that like causes always produce like effects; and, therefore, any man or woman who learns to do things in this certain way will infallibly get rich.' His central argument is that 'the man or woman who will act and think in a certain way' will achieve their desires.

These three books, along with dozens of books to follow, have evolved into the new-age buzzword theory of *intention* or 'intentionality', otherwise known as the power of positive thinking or a belief that one's mental disposition attracts similar external circumstances and events, i.e. one's mental intentions and attitudes draw people and things of like intention and attitude to oneself.[83] This type of logic, over the last century, has been popular in the self-help and motivational circuits. In 2004, however, the intention - law of attraction theory found a new advocate.

In October, 2004, Australian television writer and producer Rhonda Byrne was struggling with various setbacks or as she says 'my life had collapsed around me', namely a recent divorce, the death of her father, and a budget overrun on a series called 'Sensing Murder', she was producing for Australian television. In this state of turmoil, one day her daughter handed her a copy of Wattles' 1910 book, which supposedly contained for her the 'secret' of life. Resultantly, as she says, this book stimulated her to read 'hundreds of books' in following two months (this is clearly a great exaggeration) to trace back through history the people who knew this 'secret'.

As to her purported 150+ book per month reading rate, even the studious Rain Man savant Kim Peek, for comparison, doesen't read that fast. Peek has a reading rate of about a book per hour and he can recall 12,000 books from memory.[162] Thus, if he started reading when he was two, over the last 54 years, this would put him at an 18.5 book per month reading rate. In general, reading more than three books per day on a continual daily basis is difficult, particularly with respect to information load saturation. Russian chemical engineer and writer Jacques Bergier, to cite a high end example, had read his first newspaper by age two and at four he could easily read Russian, French and Hebrew; he was a natural speed-reader with an eidetic memory and till the end of his life he could read 4 to 10 books per day.[163]

In any event, by 2006 Byrne's efforts had resulted in a documentary-style film *The Secret* based on 55-interviews, totally 120-hours of film, of various teachers in the United States, who supposedly know the secret, ranging John Gray author of *Men are from Mars, Women are from Venus* to Marci Shimoff author of *Chicken Soup for the Women's Soul* to Fred Wolf as featured in *What the Bleep Do We Know!?*, along with a follow up 198-book of the same title.

Although in her book she goes off the rail with multitudes of claims of what the law of attraction is capable of, such as by claiming that Plato's first law of affinity is the law that 'determines the complete order in the universe, and every single thing you experience in your life'. To her credit, however, she does correctly cite Plato, Francis Bacon, Isaac Newton, and Johann von Goethe, as being the founders of the various laws of affinity. This in itself is a difficult fact to track down. These details aside, since its publication on November 28, 2006 Byrne's *The Secret* has become the fastest-selling book of its kind in the history of publishing, selling over 1.75 million copies in the first three months of 2007 alone. In other words, something about what she is saying seems to be filling some kind of niche, for some.

The book and the film have been popularized through recent primetime media figures such as Oprah Winfrey, Ellen DeGeneres, Larry King, and parodied on Saturday Night Live.[84] The name the 'the secret' is used here because, supposedly, Plato's first law of affinity has been kept secret over the centuries only for us now to discovery it. The DVD of the film was selling quietly on the Internet until this winter, when Oprah gave it her blessing.[85] The book *The Secret*, a paperback take on

the film, is currently a top-10 best-seller at *Amazon*.[86] This modern spin-off on the theory of affinity, according to reviews, however, has turned into a gimmick.[87]

In short, intention or mental-force theory, as popularized, currently argues that thoughts are said to have energy, vibration, and resonance that attract other thoughts of the same energy.[85] This part is loosely correct. We know, for example, that different α-, β-, and γ- molecules will dynamically organize about each other such that betas and gammas attract towards the central alpha molecules thus creating a pressure and force distribution in the reaction system, a distribution that will change according to system constraints.[88] The partial downfall in this theory is that it goes of on many tangents arguing, for example, that people can *control* the energy of the universe by doing certain things, namely, according to journalist Stephanie Whittaker, 'know what you want, feel and behave as if the object of your desire is on its way, and be open to receiving it'.[89] It argues that that if you do these three things and do not allow 'negative' thoughts to creep in the universe will manifest whatever it is you desire.[89]

Personal power advocate Lisa Nichols claims that mental intention means that 'when you think of the things you want, and focus on them with all of your intention, then the law of attraction will give you exactly what you want, every time.' These types of false statements, where authors try to sugarcoat life, are clearly detrimental to the betterment of humankind. The correct laws of attraction, as expounded on perfectly by Goethe in 1809, were detailed clearly in chapters ten and eleven herein.

The correct way to argue the intention point of view, is to note first that *desire* is the central feeling associated with an unsatisfied state.[90] This 'state' is a quantum electrodynamic state associated with internal neurostructures of an individual human molecule. A set of interactive, selectively isolated, human molecules constitutes a *thermodynamic system*.[91] Each set, on average, will evolve with the directional evolution tendencies inherent in the combined law of thermodynamics [4.27].[92] Hence, we can loosely say that when a person gets his or her personal intuitions in sync with this thermodynamic tendency that, in some cases, he or she will manifest their desires. Statistically, however, the only three biographical factors that have been rigorously found to predict whether 'natural ability' or innate potential will translate into actual talents are (1) birth order, (2) traumatic events, and (3) education and training.[93] . In addition, many people will naturally be predisposed to move in opposition to the bulk thermodynamic tendency, e.g. through deviant activities.[166]

In modern terms, we understand conceptions such as Atkinson's *mental forces* in terms of the actions resulting from the exchanges of primary and secondary field particles, e.g. photons, pheromones, money, etc. Instead of referring to 'forces' we refer to fundamental interactions, which operate by the exchange of messenger particles.[16] These exchanges, instead of just pushing bound-state structures together, or pulling them apart, changes the character of the entities that swap them.[16] These

subtle character changes, in stable bonds, create psychological and physical forces that work to hold dynamically-bound couples together in Gottman stability ratios.[94]

A good take on this picture, is the transactional analysis model of interpersonal interactions as popularized in the 1964 book *Games People Play*, a book that has sold five-million copies, by American psychologist Eric Berne. Berne's interaction model describes life as a series of games in which people interact through a patterned and predictable series of transactions that are superficially plausible but actually conceal motivations and lead to a well-defined predictable outcome. Not all interactions, however, are games; Berne also discusses procedures, rituals, and pastimes in social behavior.[95]

In short, Berne built on Freud's 1874 psychodynamic model, particularly the theory of 'ego states', i.e. analogs to mental thermodynamics states, of the mind by adding to it the conception of a *transaction* that has two parts: a stimulus and a response.[96] Moreover, in a reaction sense, 'stimulus-hunger', according to Berne, 'has the same relationship to survival of the human organism as food-hunger'. Indeed, as he states, 'not only biological but also psychological and socially, stimulus-hunger in many ways parallels the hunger for food.' Hence, according to Berne, thermodynamic states of the mind, which can be conceptualized as manifestations of specific neural networks in the brain, are changed by stimulus-seeking individual transactions that are usually part of a dynamic sequence. As such, analyzing a series of transactions will discern those gaming transactions that are successful from those that are not. In more complicated situations, according to Berne, to keep the drama going, people will switch roles with each other, or even bring in third parties, forming a *triangle of interaction*.[97] Berne's theories originated such sayings as 'Boy, has he got your number' and others. By updating Berne's transaction theory, being one example, with the modern-day physics model of forces in terms of 'exchanges', we can thus can better model the older theories of mental forces and the like.

In sum, throughout history, numerous living force theories, each having tidbits of truisms to them, have come and gone, although some have found reappearance in the from of verbalized new age theories, such as *intention*. To elaborate, according to Scottish biochemist Graeme Hunter, from his 2000 book *Vital Forces – the Discovery of the Molecular Basis of Life*, the biochemical revolution, 1770–1970, 'overthrew the outdated vitalistic belief that the characteristic features of living organisms were manifestations of a special force'. The biochemical revolution, according to Hunter, had four periods. From 1780 to 1850, there was 'animal chemistry' characterized by the elemental analysis of organic compounds. Then came 'physiological chemistry', 1850 to 1900, characterized by the development of theories, particularly valence theories, describing the ways in which atoms were arranged in compounds, and the application of these theories to small organic molecules. The third period, that of 'biochemistry', about 1900 to 1940, was

characterized by the analysis of the inter-conversions of simple organic molecules within living cells. The final stage of the biochemical revolution was the period of 'molecular biology', 1940 to 1970, typified by the structural analysis of complex organic molecules, in particular by X-ray diffraction techniques.

In modern times, this biochemical revolution has branched off into the newer fields of computational chemistry (1980s), supramolecular chemistry (1990s), and nanochemistry (2000s); the newest, of course, will be human chemistry (2010s).[98] It is now an absolute fact that there is no extra-special force yet to be discovered that seemingly regulates human life. Yet, when it comes to discerning human social forces in terms of the basic physical forces, the picture becomes blurred. Hunter, for example, states 'taken to an extreme, the current historiographic fashion may create the impression that scientists are the helpless agents of *social forces*, and therefore their motivations are biases are irrelevant.' In other words, after presenting a nice historical overview of how the biochemical revolution over-threw the various false or nonsensical forces, he goes and throws out the 'social forces' term, as though it were defined in physics as a force. This is not the case. No one has satisfactorily defined the social force enough so that everyone knows what it is.

To compound this issue is the commonly used phrase: certain people 'naturally gravitate together'. The force of gravitation, however, is not what defines the human chemical bond. Yet there are ways in which the gravitational force regulates human life. The amount of sunlight each human molecule receives per daily reaction cycle, for example, is a decisive factor controlled by the gravitational force. The female menstrual cycle, on average, is one *lunar month*, i.e. 27.3 days, which is the time it takes the moon to complete one full orbit of the earth, measured with respect to the stars. Similarly, just as the average menstrual cycle is about 28 days in length, the human body sheds a layer of skin approximately every 28 days.[99] The human gestation period is exactly 10 lunar months. People eat an average of 8 percent more food during a full moon as compared to a new moon, but drink 26 percent less alcohol.[100] A person's serotonin levels increase in proportion to the amount of direct sunlight received; hence, people tend to have higher serotonin levels in the summer than compared to winter levels.[101] Similarly, summer babies, i.e. people born during summer months, throughout their life, well tend to be more depressed, on average, as compared to winter babies.

To give an example of how people utilize combinations of the electromagnetic and the gravitational forces to characterize the process of human bonding reactions, American biologist Timothy Perper, who between 1979 to 1981 studied the mating behaviors of over 500 couples in the Philadelphia area, states that:[102]

> "Finding a mate [is] almost completely a personal matter of luck, good chemistry, good vibes, [and] the stars."

In his 1985 book *Sex Signals – the Biology of Love*, Perper argues that our biological behavior revolves around 'the ability and desire to bond intimately with another person,' a process which, according to Perper, is at the 'biosocial core or our search for love and intimacy.' He explains that the warp and weft of this bonding purpose revolves around the 'courtship sequence', i.e. human mating reaction mechanisms, and 'biosocial functionality', i.e. the function of the human molecule in society.

In Perper's definition above, we note the use the word 'stars' in connection to good chemistry. This touches on the remotely negligible sideline topic of planetary orientations in relation to human chemical reactions. Throughout history and in modern times, people have argued that the birth-date of a person in relation to how the stars and planets were aligned at that moment will pre-determine how and who that person will react with.[103] According to a 2001 Gallup Organization poll, for example, 32 percent of Americans aged 18 to 29 believe in astrology or that the position of stars and planets can affect people's lives.[104]

Many argue that modern astrology can give advice on dating or help explain personalities.[105] Although this line of argument has found little respect in the scientific community, due to a basic lack of rigorous scientific confirmation, it is currently a very popular mode of choosing mates and dates for many.[106] On MSN, for example, in the 'AstroLove' section, one can input data such as the date, time, and place of birth of each potential reactant, and for $14.95 get a star compatibility report to 'check the love potential between you and your partner, or potential partner.'[107]

In human chemistry, we estimate that celestial alignments will play a small but statistically insignificant role in predetermining human chemical reactions.[108] To go through one example, it is known that environmental factors such as light and dark, heat and cold, the season of the year, and the experience we have are all able to regulate the secretion of hormones of the gonads, adrenals, and thyroid gland, which have direct impact on gene expression throughout the development and adult life.[109] Hence, for example, a baby human molecule that is assembled when the earth is at *perihelion*, i.e. the earth-sun configuration in which the earth and the sun are closest in proximity, but where the length of daylight is the shortest, will likely have a significantly different intrauterine experience, e.g. lower circulating serotonin levels, than as compared to an embryo developed during *aphelion*, i.e. when the earth and the sun are distally related, but where the daylight hours are the longest.

In 2008, for example, the date for perihelion will be January 3 and the date for aphelion will be July 4. Thus, a baby assembled intrauterine during the six months of the perihelion season will likely differ neurochemically and hormonally than as compared to an aphelion season baby. Subsequently, if one were to study the pairing behaviors of at least 100,000 people, studied over multiple decades, we would likely find, according to the *opposites attract hypothesis*, a theory that is mostly based on physiology patterns, e.g. MHC attachment patterns, that parings of dissimilar months

would tend to bond tighter than like month pairings. This, however, would likely be a negligible effect. In a chemistry lab, for instance, to predict the feasibility of any given reaction, chemists consult thermodynamics tables, not astronomical tables. In human chemistry, subsequently, we should expect thermodynamics tables to be the main predictor of human reactions, not the stars.

These basic examples are all instances of how the gravitational force indirectly influences the operation of the more dominant electromagnetic force in human life. In addition, to further compound things, the force of gravitation, as most agree, is an enhanced or modified variation of a chemical bond. That is, when planets, stars, and galaxies, etc., are considered as 'large molecular structures' the attachment would be arguably *large chemical bonds* that hold these structures together. Hence, the gravitational force should more aptly be characterized as a type of chemical-gravitation.[110] The equation that defines the force of gravitation is:

$$\Phi = G\frac{mM}{r^2} \qquad [6.12]$$

This expression is known as Newton's *law of universal gravitation*, where Φ is the magnitude of the gravitational force between the two masses, G is the gravitational constant, m is the mass of one body, M is the mass of a second body, and r is the is the distance between the two point masses.[111]

To elaborate further on these related yet scatter viewpoints, we note that only three of the four fundamental forces have direct influence on the human chemical bond. Firstly, the force of gravitation has an indirect influence in driving human life, e.g. by regulating neurotransmitter or hormonal levels.[109] Second, the bulk reaction process of human life is driven predominately and directly, in a quantum stimulative manner, by the electromagnetic force, where the carrier is the photon, e.g. as in visually seeing something attractive and then being, however slightly, naturally compelled to move towards that stimulus.[112] The energy for human mate selection, for example, according to American mate selection psychologist David Klimek, 'originates in sexuality, i.e. when an individual accidentally or intentionally enters the *perceptual field* (electromagnetic field) of another, there is an instantaneous, preconscious evaluation of attractiveness and sexual desireability.'[113] Third, the weak nuclear force has a trivial role in the process of human life, e.g. as in causing radioactive-induced cancer.[114] Lastly, as far as we know, the strong nuclear force has no bearing on human life, i.e. its effectiveness is confined to subatomic range, i.e. quark-gluon, interactions.

This force delineation, however, is far from obvious. No scientist, to date, has successfully explained the mechanism of operation of the electromagnetic force in human life. This leaves the layperson in a state of perpetual puzzlement. In other words, for the average person, if in the universe there are four fundamental forces,

and if according to agreement human units are bound together via a force, then which of the four forces are we discussing?

To provide an example of the general confusion that exists in current literature in regards to this force paradox, American historian Diane Ackerman in her 1994 book *A Natural History of Love* states: '…love seeps into the machinery of life to keep generation after generation in motion. We think of love as a positive force that somehow ennobles the one feeling in.' Moreover, she declares: 'the world is filled with lonely hearts … most are like planets in orbit around others—bound by *gravity* of the human condition, trailing in one another's wake, but doomed never to touch.' In addition, as she states, over the course of life 'people usually undergo a series of crushes, infatuations, and loves between infancy and adulthood. They learn to make *magnetic attachments*, whose power they feel in their cells, in their bones. Thinking about the loved one steers their every thought, and they would die rather than break the *force field* of their devotion. It is as if they were two stars, tightly orbiting each other, each feeding on the other's *gravity*.' Ackerman, as we see, has poetically mixed the starry gravitational force with the more potent electromagnetic force so to euphemistically characterize the phenomenon of love. To summarize Ackerman's point of view, essentially, as we have all heard:

> Certain people naturally *gravitate* together.

This, however, is a misnomer. Correctly, it should read:

> Certain people naturally *electromagnetate* together.

In other words, when we see, hear, or touch a stimulus and are thus, consciously or unconsciously, compelled to move towards or away from that stimulus, the actuation of this dynamic is the electromagnetic force at work. To elaborate, following our early developmental stage involving conscious and unconscious interactions with our pre-adolescence attachments, e.g. the mother-infant bond, sibling-sibling bond, early friendship bonds, etc., which thus function as prototypes for later interactions, to quote Klimek, referring to specifically the maternal-bond, 'as this first relationship is renounced during adolescence, a definite set of unconscious preferences, attractions, and revulsions emerge toward *types* of people.' These attachment behaviors are mediated by the electromagnetic force. In relation to this force, however, the force of gravitation indirectly regulates attachment behaviors, e.g. when cerebral serotonin levels are higher, such as during the spring and summer months, people are more confident, and will mate more; likewise estrogen, the hormone that generates *estrus*, i.e. the state of sexual excitability during which a female, of most mammals, will accept the male and is capable of conceiving, is regulated by the gravitational force.

The phenomenon of love, throughout history, has similarly been associated with heat, fire, burning, and passion, often phrased in such a manner as though the reaction process of human love were in fact an evolutionary descendent of a basic combustion reaction. Novelist Sevi Regis, for example, states 'we know that love exists, not only as a feeling, as an act of one's will, or as a relational status, but also as a *substance*. How do we know? Because people are moved and changed by it. It keeps things alive, and without it, they die. It makes them grow, and without it, they are stunted.' He continues 'it is the most inspiring *force* on earth: the desire to love and be loved. It is a nutrient for the heart, and every other part of a living being. Everything that lives *responds* to love and rejoices when in *union* with it. It is also an eternal *substance* that once created, can never die, even though it may go into a sleep state, it can always be reawakened, as the spring. It has its own language and expresses itself in poetic mysteries, ubiquitous to all things, for those who can find it. It is a *fire* that *combusts* within a person and grows from that *explosion*, a body of love, an essence, mist, or *flame* that cannot dwell alone.'

Here again, we find the layperson mixing many intuitively truthful terms and concepts together, but without any real or rigorous theoretical framework. Heat is closely association to the powerful human term passion, defined as intense, driving, over mastering feeling or conviction, as in a strong liking or desire for or devotion to some activity or person.[115] The conception that love is fire that combusts within a person, however, is only a close approximation. This heat theory originated with Hippocrates, the father of medicine, who in 460 BC postulated that 'heat, a quantity which functions to animate, derives from an internal fire located in the left ventricle.'

In modern terms, a *combustion reaction*, which is a distant analog in concept to the basic human reproductive reaction, is a process in which hydrocarbon molecules electromagnetically react with oxygen molecules; such as, for example, the propane molecule C_3H_8 combustion reaction shown below:

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O \qquad [13.7]$$

In this simple reaction, what occurs is that first the lives of two separately unique (2-element) molecules, C_3H_8 and O_2, kinetically run into each other, i.e. they are pulled *uncontrollably* towards each other, in the 'initial state', then swap atomic material, i.e. *H* and *O* atoms, in the 'transition state', so to emerge 'transformed' in the 'final state' as two new entities, i.e. two separately unique (2-element) molecules, i.e. CO_2 and H_2O, newly formed, whereby energy in the form of heat and work is evolved in the process.[116] This reaction is invariably of the form:

$$A + B \rightarrow C + D \qquad [13.8]$$

By direct extrapolation, this would correlate in the human reaction sphere as:

$$Mx + Fy \rightarrow MxFy + Bc \quad [4.29]$$

In this human molecular reaction, what occurs is that first the lives of two separately unique (26-element) molecules, *Mx* and *Fy*, kinetically run into each other, i.e. they are pulled *uncontrollably* towards each other, in the 'initial state', then swap atomic material, namely gametes, which are specialized germ cells that fuse with each other during fertilization, in the 'transition state', so to emerge 'transformed' in the 'final state' as two new entities, i.e. two separately unique (26-element) molecules, *MxFy* and *Bc*, newly formed, in which resultantly energy in the form of heat and work are evolved in the multi-year process. Verbally, this love reaction process is often stated in terms of 'the universal social, emotional, and psychological forces which propel men and women into pairing.'[117] Statistically, as mentioned, 85% of people will go through this human chemical reaction.[118]

The force in both reaction situations, combustion and reproduction, is the same, namely the electromagnetic force. From another perspective, the electromagnetic force can be defined in terms of 'potentials'. All human social behavior, according to Venezuelan chemical engineer Erich Müller, including love and hate, is governed by an 'interhuman potential' similar to that of insignificant molecules.[119] These basic interhuman potentials are essentially Maxwellian electromagnetic potentials that can be quantified in thermodynamic terms. Said another way, on the surface of the earth, it's not gravitational potentials that direct human behavior, but the electromagnetic force. To elaborate, as Albert Einstein once famously stated:

> "Gravitation cannot be held responsible for people falling in love."

Although Einstein was oversimplifying, it's not gravitation, predominately, that drives human chemical reactions, but rather it's the electromagnetic force on the interpersonal scale. In all chemical bonds, it is the electromagnetic force at work.

Human chemical bond – defined:

As Einstein so clearly stated, gravity is not what causes people to fall in life, rather it is the electromagnetic force. In more detail, we set forth the following definition:

Human chemical bond – an electromagnetic induced stabilizing, attractive-to-repulsive, field-particle mediated, cohesive force functioning to hold human molecules together into bound-state entities, as relationships, family structures, and social collectives.

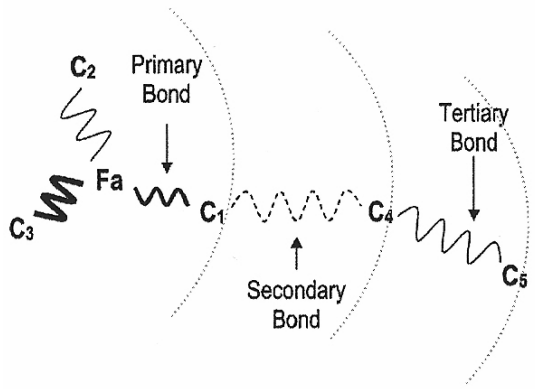
In short, whenever attraction, related to field particle exchange, outweighs repulsion, related to field particle exchange, then those attached matter particles, as humans, are held in place as if an apparent bond were in existence.[16] In human life, field particle exchange is commonly known to us perceptually as 'sensory exchange'; in minutia detail, however, these exchanges result according to photon-electron interactions. Attraction-to-repulsion movement dynamics is what accounts for the formation of all bonded structures in the universe.

The definition above is the core definition of human structural bonding. In a more advanced and detailed analysis, however, we can expand and elaborate on this core definition, per unique situation, using affixers and qualifiers. Through human molecular orbital theory, we can distinguish between those human chemical bonds that have orbital overlap from those that do not. Specifically, a *proximate chemical bond*, is one in which there is reoccurring orbital overlap and primary or secondary field particle exchange. These can also be referred to as 'immediate bonds'. A *non-proximate chemical bond* is one in which there is no orbital overlap, but where there is primary or secondary field particle exchange. These can also be referred to as 'distal bonds'.

Friends, family, associates, or distant relationships, etc., that live in separated cities, states, or countries that could have moderate to strong bonds to each other, as maintained through emails, letters, phone calls, live video-feed, etc., for example, might not have daily, weekly, monthly, or even seasonal orbital overlap, i.e. direct or immediate physical contact, but only occasionally. These can be quantified and defined as distal or non-proximate bonds. In diurnal interactions, weekly situations, or bi-weekly activities, etc., interactive people such as friends, family, neighbors, associates, or co-workers, etc., will be near in proximity, on a reoccurring basis, and will likely have orbital overlap. These can be quantified and defined as immediate or proximate bonds.

We can define *e-bonds*, i.e. 'electronic bonds', as situations involving internet connections, chat-room relationships, talk-page interactions, etc. Similarly, we can define *transient chemical bonds* to be those that, although they may be significant, come and go in a person's life. Transient bonds are those that pass especially quickly into and out of existence and as such are 'transitory'. A person who passes through or by a place with only a brief stay or sojourn will likely form a number of transient bonds.

In terms of defining layered bonding arrays or structures of bonds in human life, especially with reference to the *rhizome family* structure, we can define primary, secondary, and tertiary human chemical bonds, visually, such as shown below:



Primary, secondary, and tertiary human chemical bonds

In this diagram, we see a real-life example, in which a father Fa is bonded to three offspring, C_1, C_2, and C_3, from one wife; one of which C_1 is bonded to a fourth step-sibling C_4 from a second wife; who is in turn bonded to a fifth step-sibling C_5 from a third wife. The sinusoidal lines (waves) are used to indicate that the chemical bond is mediated via the electromagnetic force, which varies in strength, as indicated by the line thickness, i.e. from thin dotted (weak) to thick solid (strong). Moreover, it can be shown, knowing that the electromagnetic field carries energy, that in any typical family structure, such as this, that more energy will be transferred to some siblings and less to others; depending upon the arrangements of their bonded relationships.

Historically, in representing chemical bonds, stemming from lecture notes of the late 18th century affinity chemists, in particular Cullen (brackets and arrows), Black (lever diagrams), Demachy (dotted affinity lines), Bergman (letter proximity), and then in modern times Lewis (dots, double bonds, triple bonds, etc.), symbols have been used to signify various types of chemical bonds. Here, in a similar manner, we will present a few intuitive rules for representing human chemical bonds. Firstly, between two human molecular species *A* and *B*, we will set the following basic rules of chemical bond strength, varying according to symbol use:

$$\underset{\text{(weaker bonds)}}{\text{A---B}} < \text{A--B} < \text{A-B} < \text{A=B} < \text{A}\equiv\text{B} < \underset{\text{(stronger bonds)}}{\text{AB}}$$

In an approximate sense, dashes (- - -) represent weaker or less dominant social associations, ties, or acquaintances, where as the AB bond, showing no dashes in between the pair, represents a full-on relationship, where the pair is bonded so tight that it is seen, by most people, as a single molecular entity.



Couple (A≡B) with 'good' chemistry

In other words, A---B is a very weakly attached pair, A--B is semi-attached, A-B is attach to a significant degree, A=B a relatively strong attachment, A≡B is a strongly attached couple, and AB is an extremely strongly attachment couple. When referring to a tight pair, bound in a happy long-term relationship, singular terms would often be used, e.g. 'they' are a good couple, let's go with 'them', 'their' house is nice, let's watch 'Tom-n-Jerry', the 'Joneses' are path-breakers, etc. The middle variations of bonds, i.e. single dash, double dash, double bond, triple bond, etc., can be used in various ways depending on the *state of the bond* or relationship as we will discuss.

Beyond these basic representations, symbols can be used to facilitate discussion in other situations. The A 'tilde' B attachment, i.e. A~B, can be used to fit situations where the above scheme lacks in utility, but where a basic electromagnetic bond is to be signified. The tilde (~), in which the wave represents force, signifies that there is some variation of proximate or distal electromagnetic bond attachment, e.g. phone-tag, letter exchanges, an Internet connection, a neighbor, or someone seen daily, but where there is no verbal exchange, etc. The integral relationship A∫B is one that is essential to completeness. A bottom cursor, i.e. an A_B bond, can be used to represent a straight physical (visceral) attachment, e.g. 'sex buddies' or where two people are attached through their roots. A degree symbol, i.e. A°B, can represent a mental connection. A dividing line, i.e. A / B, can represent an unbalanced relationship. A not equal sign, i.e. A≠B, can represent two people that don't click, a box symbol, i.e. A□B, can represent two people in an arrangement, where two people are boxed in, or where to people are at odds with each other, etc. The intersection symbol, i.e. A∩B, can represent two lives intersected in some way. The top bar, i.e. A‾B, can represent a social connection, a play on the stereotype that 'top hats' are often associated with social class and the links and predispositions mediated therefrom. A vertical dividing line, i.e. A|B, can be used to represent two people divided in some way or an unstable pair that is under the same roof but living in the

form of 'parallel lives', as typically occurs prior to a divorce. Other symbols may be utilized where fonts allow. These are only meant to be loose examples.

In a more advanced analysis, a rudimentary *human valence bond theory* can be employed; where each species will have a chemical bond charge, +12 through -12, assigned used to represent a valence state. That is, according to a meta-analysis of the dominant publications in the related bonding fields of evolutionary psychology, physical attractiveness research, beauty science, and mate section, namely: (1) David Buss' 1994 *The Evolution of Desire*, (2) Geoffrey Miller's 2001 *The Mating Mind – How Sexual Choice Shaped the Evolution of Human Nature,* (3) Jared Diamond's 1997 *Why is Sex Fun? – the Evolution of Human Sexuality,* (4) John Girbbin and Jeremy Cherfas' 2001 *The Mating Game – in Search of the Meaning of Sex,* (5) Leil Lowndes' 1996 *How to Make Anyone Fall in Love with You*, (6) James Gould and Carol Gould's 1997 *Sexual Selection – Mate Choice and Courtship in Nature,* (7) Bobby Low's 2000 *Why Sex Matters – a Darwin Look at Human Behavior,* (8) Kevin Leman's 2001 *The Birth Order Connection – Finding and Keeping the Love of Your Life,* (9) Joann Rodgers' 2001 *Sex – a Natural History,* (10) Desmond Morris' 1997 *The Human Sexes – a Natural History of Man and Women*, (11) Nancy Etcoff's 2000 *Survival of the Prettiest – the Science of Beauty,* (12) Gillian Rhodes and Leslie Zebrowitz' 2002 *Facial Attractiveness – Evolutionary, Cognitive, and Social Perspectives,* (13) Brian Bates and John Cleese's 2001 *The Human Face,* (14) Helen Fisher's 1992 *Anatomy of Love – a Natural History of Mating, Marriage, and Why We Stray,* (15) Lynn Margulis and Dorion Sagan's 1997 *What Is Sex?* and (16) Niles Eldredge' 2004 *Why We Do It – Rethinking Sex and the Selfish Gene,* it is found that humans desire twelve dominant areas of attachment in their mate, seven physical attachment points and five mental or neurological attachment points.[120]

In human thermodynamic terms, the 'dodecabond model' correlates these twelve points of attachment with seven enthalpic, i.e. H_{AVE}, H_{AGE}, H_S, H_X, H_L, H_F, and H_C, and five entropic factors, i.e. S_P, S_O, S_I, S_S, and S_N, as described in chapter nine. In this manner, using chemical bond shorthand, with respect to intimate relationships, each dash will represent four thermodynamic *bands* of attachment, namely:

Symbol	Description
A-B	two people attached at *four* thermodynamic bands
A=B	two people attached at *eight* thermodynamic bands
A≡B	two people attached at *twelve* thermodynamic bands
AB	two people tightly attached at *twelve* thermodynamic bands

We will also refer to these 'thermodynamic bands' as *ties* or *links*. The twelfth century Middle English word 'band' means something that binds, ties, or restrains. The word band can also refer to something that confines or constricts while allowing a degree of movement.[2] Thus, for instance, if one is strongly attached to another

person due his or her level of intellect, an entropic bonding factor S_I, we can say that this specific *band* of thermodynamic attachment functions as a strong adhesion point, independent of the condition of other bands. If someone had a strong weakness for valedictorians, for instance, that band of attachment, as quantified via entropy of intellect in the potential relationship, would serve as a thermodynamic anchoring point in the energetics of the bond.

To give a terminology use example, in the 2006 *National Geographic* article 'Love the Chemical Reaction', photojournalist Lauren Slater asks 'does passion necessarily diminish over time? Can a marriage be good when Eros is replaced with friendship, or even economic partnership, two people bound by bank accounts?' Referring to her eight-year marriage, she states 'the *ties* that bind have been frayed by money and mortgages and children, those little imps who somehow manage to tighten the knot while weakening its actual fibers.'

To quantify these types of human chemical bond descriptions, we will utilize a thermodynamic valence bond model. That is, we will let the following human molecular structure: A≡B represent an extremely stable relationship, such as a happy marriage, attached at all twelve points of attachment. Such a species, owing to its great stability, would be relatively non-reactive, from a dating market perspective. Once single 'bands', i.e. one of the twelve thermodynamic ties, begin to dissolve or are broken, e.g. a wife gains weight (a change in H_F) or a husband loses his care-free personality (a change in S_P), then a person (or couple) would be then characterized by a *relationship charge valence*; a plus charge, e.g. +1, +2, +3, +4, etc., to indicate that one or more bands are missing, and a minus charge, e.g. -1, -2, -3, -4, etc., to indicate that a person or couple has extra bands with which they can donate or share.

If two bands of the dodecabond in a couple break, for example, we would define the dihumanide species with a charge of $A{\equiv}B^{+2}$ and the species would be less stable than compared to the fully bonded A≡B species. Likewise, if a single unattached human molecule was in possession of an overabundance of wealth S_O, humor S_P, inner nature S_N, fitness H_F, or symmetry H_S, with which they could give to another who was in need or lack of these decisive qualities, then that person would function as a valence band *donor*, having a negative charge, e.g. B^{-4}, whereas the recipient, lacking in these qualities would be the valence band *acceptor*, having a positive charge, e.g. A^{+3}.

In this example, if this donor and this acceptor were to bond, so to yield the coupling AB^{-1}, their resultant combined valence would be -1, and they would be more stable as a result. This logic helps to explain the bonding phenomenon in which people tend to pair up in such a manner with others who compliment one's own weaknesses or insecurities. These valence band charge distinctions allow us to better characterize the endergonic-exergonic relationships found ubiquitously in biology.

In this manner, we can utilize a combination of thermodynamics, symbols, and valences to better characterize the 'state' of relationships and marriages as they react

and evolve. Thus, for example, the $A|B^{+10}$ species would represent a pair living as cohabitating strangers under one roof, i.e. 'parallel lives', with only two connective bands holding them together. Similarly, we can use this theory to describe how a person's valence changes as they grow, evolve and or encounter difficulties and set-backs in life. We might assign a newborn human molecule with a large positive valence, such as A^{+8}; meaning that, from a friendship, social, and or sexual selection point of view, a newborn will be lacking in the majority of typical bonding affixers, such as humor, intellect, status, inner nature, values, sexuality, wealth, fitness, etc., but will, on average, develop these *banding sites* as they grow.

Thus, for example, a major 'life change' would correspond to a valence change in terms of previously latent but now potential chemical bonding capacities, e.g. school change, job transition, empty nest syndrome, retirement, etc.[121] The decisive event in which a man who loses his job, would likely affect other significant bonding factors, namely personality, character, dependability, possessions, status, prestige, or possibly inner nature. These changes could then be quantified in terms of a band valence change, e.g. $A^{-2} \rightarrow A^{+4}$, a transition period that is technically defined as a valence band ionization reaction (transformation). That is, previously, when he was very successful, A^{-2}, he was a good catch and everyone wanted to bond to him, yet when he lost his job his 'band valence sites' were affected A^{+4}, such that he lost his previous levels of band desirability, and as such he fails to bond to people. Likewise, a woman who gets a modeling contract finds soon enough that everyone wants to bond to her as compared to her previous non-contract 'status', a factor that correlates to changes in entropy of status S_S, and thus a valence change, e.g. $B \rightarrow B^{-3}$.

This human molecular valence bond theory is modeled, of course, on American physical chemist Gilbert Lewis' 1902 *cubic atom model*, where cubes attach to each other to compliment their bonding sites, a bonding theory that latter evolved into the *octet rule* presented in Lewis' 1916 article the 'Atom and the Molecule', where he showed that atoms tend to bond with other atoms to create a noble gas valence shell electron configuration, in which the bond orbitals are filled with eight electrons.[122] In human terms, this translates to the effect that human molecules tend to bond and to rearrange with each other, over daily and evolutionary time frames, so to achieve a *noble band* valence shell configuration in orbital state.

In small atomic models, by comparison, if an atom or species in its normal state is missing electrons, it then has a positive electron valence, whereas if it has extra electrons it then has a negative electron valence. The hydrogen ion H^+, for example, is missing one electron, where as the SO_4^{-2} species has two extra electrons. Hence, if these two species were near to each other in a system, they would have a tendency to bond forming the attached species HSO_4^{-1}, being more stable as a unit. Thus, if a human molecular species, in its normal state, is missing band qualities, it then has a positive band valence; whereas if it has extra band qualities it then has a negative

band valence. People in charged valence states will then naturally tend to react and to bond with others so appease their valence insecurities and tendencies.

To elaborate, in fields such as psychology and neuroscience, *valence* refers to the emotional value associated with a stimulus; e.g., a familiar face can have positive valence. Merriam-Webster defines *valence* as the degree of attractiveness an individual, activity, or object possesses as a behavior. Similarly, in Miller and Rodger's 2001 *The Ontogeny of Human Bonding Systems*, we are told 'with respect to bonding schemas, the arousers and the enhancers are of particular interest. We will refer to these collectively as attractors, recognizing that the two functions may be separate and may not both apply to a given stimulus. Nevertheless, many attractors serve both to increase the chance that we will notice another person and to attach *affective valence* to them.'[123] Thus, according to human beauty theorist Nancy Etcoff, 'when a beautiful women or handsome man enters a room filled with people, a variety of visual and other characteristics, some of which may be emphasized, or diminished by makeup, clothing, ornaments, etc., stimulate us to take notice and arouse or interest.'[124]

Subsequently, human molecular valance bonding tendencies, whether explained in psychological, neuroscience, or thermodynamic terms, help to explain stability and reactivity in human molecules. In general, the greater the valence charge, the greater the reactivity; whereas, conversely, those with a *noble bonding* configuration, analogous to the stable *noble gas* electron valence shell configuration, human or atomic, e.g. a very strong marriage, or someone in a happy job, etc., will have the greatest stability.[125] Likewise, a *neon family* is an extremely stable nuclear family.[126]

To review, human chemical bonding is electromagnetic in composition, yet the gravitation has an indirect influence. In addition, in human chemistry a central goal is to bring a contiguity between basic chemical bonding theory and terminology, i.e. *banana-bond*, *mechanical bond*, *non-covalent bond*, *hydrogen bond*, *triple-bond*, etc., with those psychological bonding terminologies and theories used in the non-technical sciences, such as *attachment* (psychology), *weak ties* (sociology), *pair-bond* (anthropology), *capture bond* (criminology), etc.[127] All of these various 'bonding theories', human or otherwise, are characterizations of the chemical bonds, which in detail are each quantum electrodynamic in structure, and from a quantum chemistry point of view, are based in principle on Heisenberg's 1932 exchange force theory.[128]

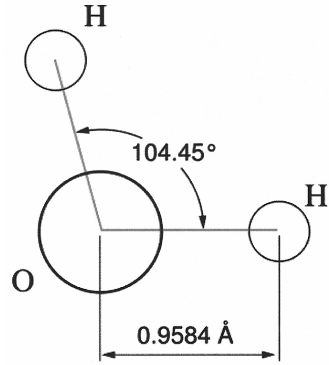
To elaborate, an exchange force residing in the chemical bond, A≡B, between two human molecules, for instance, is 'a force that results from the continued interaction of particles in a manner that bonds their hosts together'.[164] In a marriage bond, for example, what is being exchanged subsequently accounts for the force that holds the pair together. Hence, if one studies the exchanges, one will understand the force. If the exchanges are principally of the negative variety, such as verbal belittlements, the force will be that of the repulsive type and thus will act to dissolve

the bond. If the exchanges are principally of the positive variety, such emotional encouragement, the force will be that of the attractive type and thus will act to solidify the bond.

A concept related to chemical bonding is bond geometry, i.e. the arrangement of chemical bonds in three-dimensions or two dimensions in the human molecular case. Bond geometry is a generalized way to gauge the spatial orientation of any particular bond, human or otherwise. Typically, in terms of the length of bonds, the shorter the bond, the stronger the bond.[129]

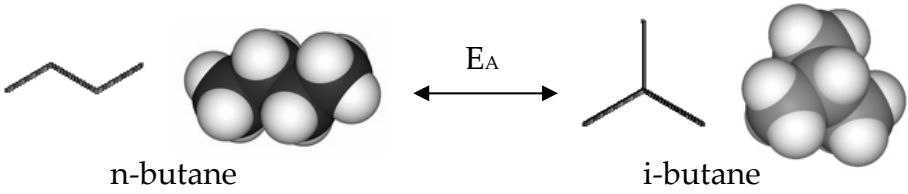
Bonding geometry

In chemistry, *molecular structure* or molecular geometry is the three-dimensional arrangement of the atoms that constitute a molecule. The position of each atom is determined by the nature of the chemical bonds by which it is connected to its neighboring atoms. The molecular geometry can be described by the positions of these atoms in space, evoking bond lengths of two joined atoms, bond angles of three connected atoms, and torsion or dihedral angles of three consecutive bonds.[130] Below, for example, is the molecular geometry for the water molecule:



Bonding geometry of the water molecule H_20

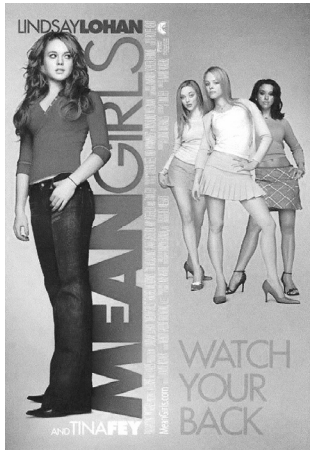
The dihedral angle, i.e. 'bond angle', in this diagram is 145.45°. The O-H bond length is 0.96E-10 meters. Larger molecules, such as butane C_4H_{10}, in which n-butane, for example, exists in the form of a bent lawn chair configuration, with two kinks in the carbon chain, $CH_3CH_2CH_2CH_3$, often exist or are found in multiple stable chemical conformations, e.g. isobutane, each of which differ in their molecular geometry, and are separated by high activation energy E_A barriers in their potential energy surface:[131]



In human bonding chemistry, in a similar manner, human *molecular structure* or attachment geometry is the three-dimensional (or two-dimensional) arrangement of the human molecules that constitute a human social structure, comprised of two or more people. Human molecular structures are multi-humanide molecules, such as di-, tri-, tetra-, or penta-humanide molecules, etc., or poly-humanide molecular social chains or relationship rings, etc.[132] In other words, when people interact and cluster together socially, e.g. two friends, three colleagues, a clique, a group, etc., each component molecule will distance themselves from each other in the bound social structure in terms of measurable average bond lengths, bond angles, and bonding geometries.[133]

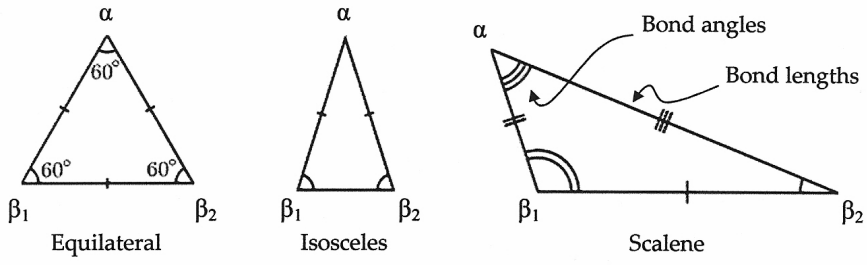
Although little actual research has been done in this area, aside from proxemics (average bond lengths) research, we can discern notable patterns via common observation, film, and books. In female clique social ranking movies such as *Heathers* (1989), *Clueless* (1995), *Legally Blonde* (2001), and *Mean Girls* (2004), we can discern the female alpha-di-beta, tri-humanide molecular clique geometry. In each of these movies, which are based on actual settings, the three most popular girls, i.e. one α-female and two β-females, at any typical high school or college setting, will form a pyramidal social ranking friendship geometry, a geometry which can be loosely discerned by looking at the DVD covers, front and back, via screen clips online, or by watching the films.[134]

In *Heathers*, for example, three of the four girls in a trend-setting clique at a suburban Midwestern high school are named Heather. They play croquet with each other and rule the school through intimidation, contempt, and sex appeal.[135] Likewise, the film *Mean Girls* is described director Curtis Cary as '*Clueless* meets *Heathers*,'[136] In these films, the alpha will sometimes go off on her own, such as to a new school in *Legally Blond*, but the betas are never far behind. When together they form a dynamic molecular bonding (triangle) geometry between that of an isosceles and scalene bonding triangle:



Bonding triangle

Mean Girls (2004): showing the *alpha-dibeta* bonding triangle (right)



Bonding geometries in the alpha di-beta clique structure

In other words, firstly the $\beta_1\beta_2$-bond, on average, will be tighter, as compared to either of the $\alpha\beta$-bonds, and thus have a shorter bond-length, comparatively. We know, for instance, from Hall's proxemics findings, that the average distance for interactions amoung good friends is 2.75 meters. Hence, by bonding tighter to each other, then this bond length average, the betas will gain strength equal to that of the more powerful alpha. Second, although the betas will typically be similar, we can assume that one of the alpha-beta bonds, such as the $\alpha\beta_1$-bond, will be subtly tighter than compared to the second alpha-beta bond, e.g. the $\alpha\beta_2$-bond. Typically, then, the inter-triangle bond angles will not match those of the isosceles bonding triangle. Together, the three molecular species will attaching in the bonding triangle and thus form a *power relationship*, in which together they will have more power as a unit than as three separate molecular species.[137]

Bonding triangles, in general, can be classified according to the relative lengths of their sides, i.e. bond lengths, and correlative dihedral bond angles. In an *equilateral triangle*, all sides are of equal length. In an *isosceles triangle*, at least two sides are of equal length. An isosceles triangle also has two congruent angles; namely, the angles opposite the congruent sides. An equilateral triangle is also an isosceles triangle, but not all isosceles triangles are equilateral triangles. In a *scalene triangle*, all sides have different lengths. The internal angles in a scalene triangle are all different.[138]

Not all molecular structures, however, have a bent or triangle shape. The carbon dioxide CO_2 molecule (O=C=O), for instance, contains two double bonds and has a linear shape. Nitrogen dioxide NO_2 has a bent-conformation with a dihedral angle 134.3°. Other examples of bonding geometries include chains, rings, tweezers, balls, tubes, chairs, etc.[139] Many of these structures can be found in human systems, such as were diagramed in chapter eight. In general, each molecular structure, human or otherwise, will have a molecular geometry indicative of the electromagnetic stability tendencies correlative with the lowest energy conformation of the various possible structures.

In terms of bond length, human or otherwise, closer tighter bonds are usually stronger than distal or long-distance bonds. Below, for example, are a few basic

bonded species and their bond length in picometers (10^{-12} meters), which shows the trend that inter-nuclei separation (bond length) decreases as the number of bonding ties (electron pair bonds) increases:[140]

Bond Type	Bond Length (pm)
C-H	107
C–O	143
C=O	121
C–C	154
C=C	133
C≡C	120
C-N	143
C=N	138
C≡N	116
N–O	136
N=O	122
O–H	96

In human molecular terms, to measure the bond length between two people, such as in a married couple in an A–B bond, we have to measure the distance between the centers of mass of the two attached human molecules. The *center of mass* is defined as the point in a body or system of bodies at which the whole mass may be considered as concentrated.[141] In human molecular orbital terms, the center of mass of one human molecule is the point at which the averaged weekly movement of the bound-state human point mass, in its set of movement orbitals, may be considered as concentrated. Thus, for example, if a person spends 50% of their time at their job and the other 50% at home, the center of mass of the that human molecule would be at a point location midway between the home and work locations.

Hence, through exacting weekly satellite tracking measurements, one should be able to find and tabulate bond lengths correlative to the dodecabond valence model in which inter-human molecular separation (bond length) decreases as the number of thermodynamic bonding ties (entropy and enthalpy links) increases, and conversely. When marriages begin to dissolve, for instance, one or both of the bonded partners will concurrently begin to spend more time away from the home, e.g. going out more, working more, getting new friends, etc. This will correlate with a change in the location of the center of mass for each dissatisfied human molecule and hence with an increase in the bond length in the paring, such as shown below, where bond lengths are indicated in kilometers:[142]

$$A{\equiv}B\ (8km) \rightarrow A{=}B\ (12km) \rightarrow A{-}B\ (16km)$$

In other words, as the relationship ties begin to break the overall human chemical bond begins to weaken and this correlates with a natural increase in inter-human molecular bond length of the pair.

Beyond these common descriptors, most human bonds, regardless of the name used, tend to be comprised of a physical component and a mental component, which can be defined as a bond distinction. In colloquial sense, people want both brains and beauty in their potential mates.

A concept related to chemical geometry is bond energy, i.e. the amount of energy a chemical bond holds. Bond energy is a generalized way to gauge the strength of any particular bond, human or otherwise. Typically, the more energy a bond possesses the stronger the bond.

Bond energy

In chemistry, the general statement or depiction of *chemical bonding* is any of the interactions that account for the association of atoms into molecules, ions, crystals, and other stable chemical species.[143] The central word in this definition is stability; all dynamic physical systems, as Bohr showed in 1914 in quantum terms and as Gottman showed in 1970 in human terms, are unified by the inherent tendency or drive to seek out stability through evolutionary bonding dynamics. Conversely, the general statement of *chemical debonding* is any of the interactions that account for the dissociation of unstable chemical species, molecules, crystals, and ions into separate atoms or components. Bonds, generally, are interactions characterized by stabilizing tendencies.

In evolving physical systems, *bonding dynamics*, i.e. energy movements which define spatial cohesions, operate according to the natural phenomenon in that when atoms, molecules, and chemical species approach one another, their nuclei and outer shell electrons interact and tend to distribute themselves in space in such a way that the total energy is lowered than it would be in any alternative arrangement.[143] If the total energy of a group of atoms, molecules, or chemical species is lower than the sum of the energies of the component units, then they bond together and the energy lowering is defined as the bonding energy.[143]

Bond energy values, according to American bond theory pioneer Linus Pauling, 'are values chosen in such a way that their sum over all of the bonds of a molecule which can be satisfactorily represented by a single valence-bond structure is equal to the enthalpy of formation of the molecule from its constituent atoms in its normal state.'[160] The value of O-H bond energy (110 kcal/mol), for example, is one-half the enthalpy of formation of H_2O (g) from 2H (g) and O (g).

Another quantity of interest in chemistry is the bond dissociation energy.[165] The bond dissociation energy of a chemical bond in a molecule, according to Pauling, 'is the energy required to break that bond alone, i.e. to split the molecule into two parts

that were previously connected by the bond under consideration.' In human molecular terms, the amount of energy required to break off a single friendship bond, for instance, would be the bond dissociation for that bond. If the friendship was on rocky ground, for instance, the bond dissociation energy would be small.

In a general manner, *bonding energy* is the energy required to disassemble a whole into separate parts or to disperse the particles of a system.[145] From another perspective, bonding or *binding* energy is the amount of energy required to separate one particle from a system of particles.[146] A bound system typically has lower potential energy than its constituent parts. This lower potential energy correlates to stability and is what functions to keep the system together. In nature, there exists an inherent tendency for systems to evolve towards potential energy wells or stability attractors, in which, by convention, this stability corresponds to a positive binding energy.

In chemistry, *bond energy* is the amount of energy associated with a bond, such as an *A-B* bond in a chemical unit, and functions as representation a measure of bond strength for that chemical bond.[147] In thermodynamics, bonding energy, symbolized by ε_{AB}, has throughout history referred to the dissociation enthalpy ΔH_D or bond dissociation energy of an *A-B* bonding, which confers on it a positive character. In current use, however, bonding energy ε_{AB} has come to be associated with the formation enthalpy ΔH_F of a bond forming reaction:

$$\varepsilon_{AB} = \Delta H_F \qquad [13.9]$$

such as in the following basic association reaction, which confers on it a negative character:[148]

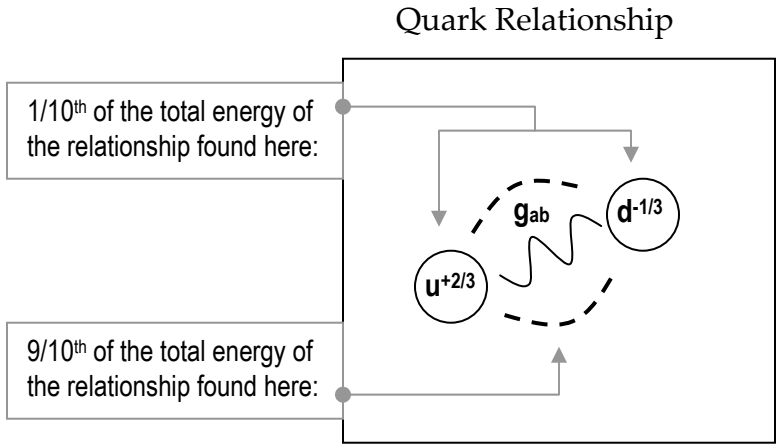
$$A + B \rightarrow AB \qquad [13.10]$$

In thermodynamics, then, an *A-B* bond has an associative enthalpy of formation that quantifies it energetic nature.

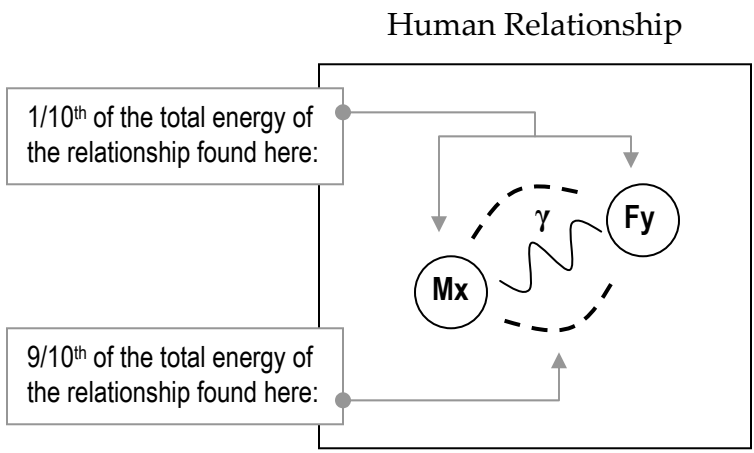
In general, all bonds in the universe have an energy associated with their nature and composition. In the science of *particle physics*, i.e. the study of subatomic behaviors, it is found that most of the mass or 'energy', as these are equivalent, via Einstein's mass-energy relation $E = mc^2$, actually resides within the bond. Within the quark-gluon bonding 'relationship' of the proton or neutron, for example, it is known that approximately $9/10^{th}$ of the mass or energy equivalent of their joint relationship actually resides within the gluon bond.[149]

Specifically, the mass of one proton, which is comprised of two up quarks *u* and one down quark *d*, is equal to 938 megaelectron volts (MeV). Yet the mass of the three quarks combined, i.e. the physical part of the proton, is only 15 MeV. In other words, most of the energy, specifically 923 MeV, or 'essence' you will, of this quark

relationship is actually found within the gluon bond. The following diagram depicts this relationship:


Quark Relationship
1/10th of the total energy of the relationship found here:
9/10th of the total energy of the relationship found here:
gab
d-1/3
u+2/3

Similarly, using this model as a basis and knowing that human bonds are photonic in nature, we will propose an energy model for human relationships. Technically, to start with, it is known that photons γ are 100 times weaker in strength as compared to gluons g_{ab}.[23] In this direction, neglecting a yet to be determined scaling factor, we will propose that $9/10^{th}$ of the mass-energy equivalent of each respective human bonded relationship actually resides in the photon bond, as shown below:


Human Relationship
1/10th of the total energy of the relationship found here:
9/10th of the total energy of the relationship found here:
γ
Fy
Mx

This relationship, to note, is only a very crude approximation. Nevertheless, future studies and measurements will only function to yield more accurate quantifications. This approximation, however, aligns well with intuition. In the majority of human relationships, within each respective bond, there exists a great deal of stabilizing energy exchange: physical reciprocation, visual feedback, conversation, emotional

resonance, emails, phone calls, letter-writing, gifts, sensual exchange, financial remuneration, information transmittal, humor, small talk, gossip, etc. Conversely, we tend to avoid interactions which are destabilizing in energetic nature.

Each type of exchange will depend on the electromagnetic nature of each photon interaction at each key interface. Wherein these exchanges occur reciprocally and spontaneously the strength of the bond will typically be greater and, as a result, carry more energy. Human bonding researchers Warren Miller and Joseph Rodgers state, in their 2001 book *Ontogeny of Human Bonding Systems*, for example, that:[123]

> Goals determine bonding investment criteria – these are species-typical survival and reproductive issues faced by the individual organism when considering the investment of energy and resources in a particular bond.

We will define the portion of the energy, in quality and content, in any human bond as 'energy density', symbolized by U_b. In general, *energy density* is the amount of energy stored in a given system or region of space per unit volume or per unit mass, depending on the context.[150]

In thermodynamics, energy density is the portion of the internal energy U of the thermodynamic system found in the working bonds, hence the subscript b. Human bonds, as is the case with all chemical bonds, are quantum electromagnetic in basic structure.[33] Along these lines, as clarified by Maxwell, electric and magnetic fields store energy.[66] In a vacuum, for example, the energy density is give by:

$$U = \frac{\varepsilon_0}{2} E^2 + \frac{1}{2\mu_0} B^2 \qquad [13.11]$$

where E is the electric field, B is the magnetic field, ε_0 is the permittivity of free space, and μ_0 is the permeability of free space. Human chemical bonds, likewise, can be quantified along the lines of [13.11], however, only in a more advanced and complicated manner. This is equivalent to the concept of bond energy used in basic chemistry in reference to small atomic or molecular bonds; the term energy density is introduced here only to ameliorate the complicated yet exacting analysis of human chemical bonding, namely that both primary and secondary field particles are involved.

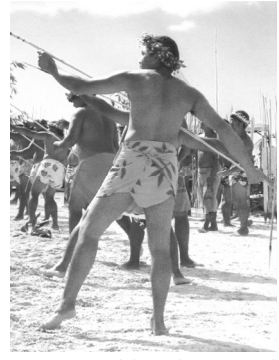
The total energy density of a person's net bonds is the sum total defining bond energy related to that person as a single dynamic molecular entity embedded within a surround social matrix. Including in this assignment are defining personal qualities and quantities such as personality, character, integrity, knowledge, humor, moral nature, information, financial resources, wealth, etc., as found within that person's total network of bonds or bonding relations, e.g. family, friends, distal relations,

acquaintances, neighbors, work relations, social connections, natural attachments, etc. Formulaically, this total energy density U_b can be defined as follows:

$$U_b = \frac{1}{2}\sum_{N=1}^{L} E_N \qquad [13.12]$$

where L is the total number of people in one person's social network, E_N is the bond energy for the Nth bond, and where N is the number for a specific bond in that social network. The dividing factor of two signifies that, on average, the contribution to the energy density of any typical bond will normally be due to the actions of two people. In other situations, however, this assignment may not hold. One individual, for example, may dominate a bond, thus contributing more to the energy density of that particular bond. This would require a more advanced analysis.

To elaborate on equation [13.12], sociologists estimate, on the high end, that within the average person's social network, i.e. family, friends, neighbors, work associates, etc., there exist about 200 people; moreover, it is estimated that we know more than 300 to 5,000 people by name.[151] On the low end, according to parent-infant bonding theorists Marshall Klaus and John Kennell, 'individuals may have from 300 to 400 acquaintances in their lifetime, but at any one time there are only a small number of persons to whom they are closely attached.'[152] In this manner, on average, L will vary from 200 to 5,000. This will depend on the valence of the person. Only about a dozen of these bonds, however, tend to be significant. When asked, for example, to make a list of the people we know whose death would leave us truly devastated, we typically list 10 to 15 names, with the average being 12 people.[153] Hence, the average person will have only a few handfuls of strong bonds but many social bonds, each varying in strength:



A javelin throwing competition (*social bonding*) at the Heiva Festival in Papeete.

The exact measure of the average bond energy in the prototypical human-human bond *H-H* will require further analysis. For comparison, the two element unions of *O-O* and *N-N* have energy densities or contents of about 1.45 and 1.65 electronvolts (eV), respectively; while the energy of the *C-C* bond, being stronger, comparatively,

is about twice as great, with an energy of 3.57 eV.[154] Crude calculations show, by comparison, that the Gibbs free energy of formation ΔG_F for one human molecule may be on the order of 4.6×10^{32} kJ/mol.[155] Hence, via [13.9] the bond energy ε_{AB} in the average human-human bond may be on the order of 7.6×10^{8} kJ per bond.[156]

The energy released in the formation of noncovalent bonds, such as between 50 atom supermolecules, by comparison, is in range of 4.2 to 21 kJ per mol.[157] This is equivalent to about 0.04 to 0.22 eV per bond. A *noncovalent bond*, technically, is a type of chemical bond, typically occurring between macromolecules, that does not involve the sharing of pairs of electrons, but rather involves more dispersed variations of electromagnetic interactions.[158] Noncovalent bonds are critical in maintaining the three-dimensional structure of large molecules, such as proteins and nucleic acids, and are involved in many biological processes in which large molecules bind specifically but transiently to one another. The human chemical bond is an evolutionary enhanced variation of a noncovalent bond.

Verbally, energy differences aside, there exist numerous ways to define a human chemical bond; each such definition must be based on the fundamentals of the basic two-electron quantum chemical bond. To review, in 1927 valence bond theory was formulated which argued essentially that a chemical bond forms when two valence electrons, in their respective atomic orbitals, work or function to hold two nuclei together, by virtue of system energy lowering effects. In 1931, building on this theory, American chemical engineer and Nobelist Linus Pauling published what some consider one of the most important papers in the history of chemistry: 'On the Nature of the Chemical Bond'. In this paper, building on the works of Lewis, and the valence bond theory of Walter Heitler and Fritz London, and his own earlier work, he presented six rules for the shared electron bond, the first three of which were already generally known:[159]

1. The electron-pair bond forms through the interaction of an unpaired electron on each of two atoms.
2. The spins of the electrons have to be opposed.
3. Once paired, the two electrons cannot take part in additional bonds.

His last three rules were new:

3. The electron-exchange terms for the bond involve only one wave function from each atom.
4. The available electrons in the lowest energy level form the strongest bonds.
5. Of two orbitals in an atom, the one that can overlap the most with an orbital from another atom will form the strongest bond, and this bond will tend to lie in the direction of the concentrated orbital.

These rules function beautifully for the characterization of the bonding behavior for between small molecules, e.g. H_2, NH_3, CO_2, CH_4, etc. For larger-sized molecules, including: *biomolecules*, e.g. $C_{20}H_{30}O$ (retinal), *macromolecules*, e.g. RNA or lipids, *supermolecules*, e.g. rotaxane or molecular knots, as well as for *bacterial molecules* through *human molecules*, however the rules for what quantifies the behavior of a chemical bond deviate significantly from Pauling's six-rules. Yet, we can discern notable patterns.

Using the advanced models of *human molecular orbital theory*, where mutually interactive activity orbitals overlap between two or more human molecules qualifies human bond, and *quantum exchange theory*, where Gottman ratios (5-to-1 being the most stable ratio) of attractive-to-repulsive primary and secondary field particle exchange interactions quantify bonding dynamics, we can understand Pauling's rules from a more advanced and evolved perspective. Rule six states that 'of two orbitals in an atom, the one that can overlap the most with an orbital from another atom will form the strongest bond, and this bond will tend to lie in the direction of the concentrated orbital.' Hence, when two people have more natural orbital overlap, in quantity, quality, and geometric direction, i.e. their activity orbitals are coincidently in the same direction, and in their ways of life, the pair will naturally tend to from stronger bonds. Rule five states that 'the available electrons in the lowest energy level form the strongest bonds.' In human molecular terms, the home orbital is the lowest energy level and within the home orbital, the bedroom is lowest of them all. In this point of view, we might be reasonable to argue that the valence electrons associated with intimate sexual behaviors, i.e. those unstable atoms found in specific regions of the central nervous systems associated with desire, will tend to contain those mental electrons associated with potentially the most potent of strong bonds.

Hence, when an external person is invited into a one's home orbital or better yet into a person's bedroom orbital, on a reoccurring basis, these core interactions of the 'available' valence electrons, of those stored mental desires, of specific sex-related neuro-atoms of those human molecules, will have the effect, on average, of forming the strongest bonds. In other words, the stimulators and releasors that actuate during mutually convivial sex will likely tend to correlate with valence shell electrons in the specific atomic structures of the brain in accordance with the evolution tendencies of the combined law of thermodynamics [4.27] and the octet rule.

Building on his article, the first and foremost basic chemical bonding definition was stated by Pauling in his famous 1939 textbook *The Nature of the Chemical Bond*, which is: 'we shall say that there is a *chemical bond* between two atoms or groups of atoms in case that the forces acting between them are such as to lead to the formation of an aggregate with sufficient stability to make it convenient for the chemist to consider it as an independent molecular species.'[160]

In human chemistry, this definition applies absolutely. In short, the group of atoms, in Pauling's definition, is the human molecule and the stable aggregate would be, for example, a bonded human couple or a social structure. Said another way, we shall say that there is a *human chemical bond* between two or more people when the forces acting between them are such as to lead to the formation of an aggregate, such as a tightly bound couple, a well-knit family, or a vigorous social structure, etc., with sufficient stability to make it convenient for the *human chemist* to consider it as an independent molecular species.

Accordingly, chemical and quantum electrodynamic details aside, many similar definitions and theories of human bonding have been proposed along the lines of Pauling's aggregate bonding definition, such as pair-bond, maternal bond, weak ties, and the more recent and interesting erotic bond, limbic bond, as well as Müller dispersion forces. In addition, many have directly focused on and developed theory around mal-bonded situations, such as placeholders, capture bonding, trauma bonding, as well as on the entire length of the often troublesome de-bonding process, e.g. decoupling theory, detachment, or shattered bonds, etc. In the following chapter, we will outline the main points of these various human bonding theories.

14 – Bond Theories:

"It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong."

Richard Feynman, American physicist

The *human chemical bond* is an electromagnetic induced, stabilizing, attractive-to-repulsive, primary and secondary field-particle mediated, cohesive exchange force functioning to hold human molecules together into bound-state entities, such as relationships, friendships, family structures, and social collectives. The force that functions in the human chemical bond is the electromagnetic force whose carrier is the photon, which together create a surrounding photonic field according to which humans react. This is the exacting and rigorous definition.

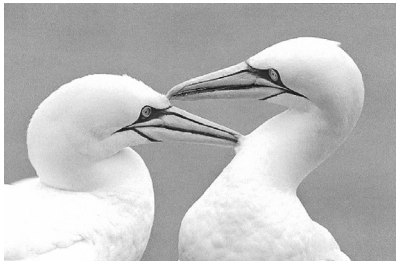
Historically, however, a number of simpler, more psychologically described, human bonding models, such as pair-bond (1932), attachment theory (1951), weak ties (1962), or paternal-bonding (1976), etc., have been successfully employed to define various aspects of the human chemical bond. In recent years, likewise, newer, more advanced theories, such as the erotic bond (1988), limbic bonding (2000), or placeholders (2003), etc., have been successfully employed in a similar manner. Moreover, building on the noted detachment theory work of John Bowlby, some have begun to study, analyze, and theorize about the slow decomposition, dissolution, or debonding process of relationship breakup, which, essentially, is the reverse of formation. Here we will touch upon the outlines of a few of these models.

In discussions of human bonding, several terms and the theories associated with them have taken on a life and popularity of their own. As such, several dominant human bond terminologies have evolved enough in theory and popularity to merit separate and unique historical discussions. These include pair bond, maternal bond, paternal bond, affectional bond, to name a few. The first to come of use is 'pair-bond' used to signifying a mating relationship or seasonal attachment of two pairs.

Pair-bond

In zoology, ethology, sociology, and evolutionary psychology, a *pair-bond* is an exclusive sexual union with a single mate at any one time, often synonymous with a monogamous relationship.[1] Originating in 1930s, in reference to birds in mating, pair bonding is a generic term signifying a monogamous relationship or a socially

monogamous relationship of either the human or animal variety, commonly used in ethology, sociobiology and evolutionary psychology.[2] Pair-bonding, usually of a fairly short duration, occurs in a variety of primate species. Some scientists speculate that prolonged bonds developed in humans along with increased sharing of food.[3]



Northern gannets pair-bonding

Examples of pair-bonding use terminologies in the sciences of ethology, biology, and evolutionary psychology, predominantly used in relation to bird matting life, include:[4]

- **Short-term pair bond**: a transient mating or associations.
- **Long-term pair bond**: bonded for a significant portion of the life cycle of that pair.
- **Life-long pair bond**: mated for the life of that pair.
- **Social pair bond**: attachments for territorial or social reasons, as in cuckold situations.
- **Clandestine pair bond**: quick extra-pair copulations.
- **Dynamic pair bonding**: e.g. gibbon mating systems being analogous to 'swingers'.
- **Serial pair bonds:** where bond formations occur in a series, i.e. one after the other.
- **Polygamous pair bonding**: where multiple pair bonds exist simultaneously.

In general, according to noted American sociobiologist Edward Wilson, animals are fundamentally polygamous.[5] Monogamy, however, will tend to evolve as a derived condition of system constraints, namely it occurs when exceptional selection pressures operate and equalize total parental investment and literally force pairs to establish sexual bonds. The fidelity of the monogamous pair bond, when it forms, will depend on the ecological and social pressures. Fidelity in a bond, according to Wilson, 'is a special condition that evolves when Darwinian advantage of cooperation in rearing offspring outweighs the advantage of either parent seeking extra mates.' Three biasing conditions are known to account for all known cases of monogamous bonding: (1) the territory is scare in resources, such that two adults are a requisite to synthesize a stabilize living arrangement; (2) the physical environment is so difficult that two adults are needed to cope with it; and (3) early breeding and a prolonged development stage are such that monogamous pairing is favored.[5]

To exemplify this logic, the oilbird of Trinidad is *believed*, i.e. genetic testing is actually required to determine mating behaviors, to form life-long pair bonds. In this species, the permanence of the pair bond stems from the combined circumstances

that the birds nest in caves, are long-lived species, and breed slowly.[6] Nesting sites along the walls of the cave are few and their scarcity appears to be the principle factor limiting the size of the population. Moreover, pairs need to work together in cooperation to defend and maintain the sites during their long reproductive lives.[5]

Another pair-bond terminology example comes from American evolutionary psychologists David Barash and Judith Lipton, as found in their the 2001 book *The Myth of Monogamy – Fidelity and Infidelity in Animals and People*: when discussing the social life of the bank swallow, they note that during the breeding season 'for about four days immediately prior to egg-laying, when copulations lead to fertilizations, the male bank swallow is very busy, attentively guarding his female.' Before this time, as well as after, that is, when her eggs are not ripe, and again after his genes are safely tucked away inside the shells, however, 'he goes seeking extra-pair copulations with the mates of other males … who, of course, are busy with defensive mate-guarding of their own.

It is unlikely, according to Barash and Lipton, that these chases are 'sexual displays', intending to enhance the *pair-bond*, as earlier literature in animal behavior has suggested. This is because first males always chase females, second males typically fight with each other as an immediate result of such chases, and third when their own female is no longer fertile, mate males typically join in chases of other females. Hence, according to these researchers, 'such males could not be solidifying an additional pair-bond, if only because no such *double-bonded* males have ever been found.' The correct term they use here, however, should be *divalent-bonded* males, signifying that the male is bonded to two females. The terms single-, double-, and triple-bond, etc., should correctly only refer to bond density descriptions between two individuals.

In recent years, some have begun to apply the term to human relationships arguing, for example, that a recent shift in technology, namely birth control and DNA testing, have created a shift in the male-female power balance thus resulting in the formation of *dynamic pair-bond* that do not exist in other species.[7]

Maternal bond

Of all human bonds, the *mother-infant bond* or 'maternal bond' is the first to develop and considered one of the strongest.[8] The maternal bond begins to develop during pregnancy; following pregnancy, the production of oxytocin during lactation increases parasympathetic activity, thus reducing anxiety and theoretically fostering bonding. It is generally understood that maternal oxytocin circulation can predispose women to form bonds and show bonding behavior.

Some hypothesize that in development there is a 'critical period' or *bonding window*, particularly in the first four years of life, and in periodic spurts thereafter, in which the mother-child bond will be cemented optimally. This bonding window is

sometimes referred to as the sensitive period.[9] The latter term implies that there is a phase of infant development during which a bonding process may be more readily accomplished than at some other phase.[10] In general, we may extrapolate this to the entire course of life, in which following transitions, i.e. graduation, job-change, or retirement, etc., as well as during new introductory periods, such as birth, entering a new school, moving to a new neighborhood, etc., that bonding windows will be open more so than as compared to other times in which bonding windows may be closed.

To elaborate on these bonding process windows, British anthropologist Ashley Montagu published a number of studies, beginning with a 1953 paper titled 'The Sensory Influences of the Skin', which expounded on the hypothesis that there is indeed a mother-infant bonding process.[11] This paper is one of earliest discussions on the bonding functionality of touch.

In the years to follow this paper, specifically in 1955, after retiring from his academic career as a professor of anthropology at Rutgers, Montagu moved to Princeton to pursue his popular writing and public appearances. He then became a well-known guest on Johnny Carson's *Tonight Show*. During these years, he directed his numerous published studies on the significant relationship of mother and infant to the public. The humanizing effects of touch informed the studies of isolation-reared monkeys and adult pathological violence that is the subject of his 1970 Time-Life documentary 'Rock A Bye Baby'.

In his popular 1978 book *Touching: the Human Significance of Skin,* was one of the first to point out the importance of skin contact during breast feeding.[12] He states 'physiologically, the nursing of her babe at her breast produces in the mother an intensification of her motherliness, the pleasurable care of her child. Psychologically, this intensification serves further to consolidate the *symbiotic bond* between herself and her child. In this bonding between mother and child, the first few minutes after birth are crucial.'[13]

Breastfeeding is also strongly believed to foster the early post-partum maternal bond, via touch, response, and mutual gazing.[14] This is not always the case, however, especially if the mother is experiencing breastfeeding problems. Many believe that early bonding ideally increases response and sensitivity to the child's needs, bolstering the quality of the mother-baby relationship; many exceptions, however, can be found of highly successful mother-baby bonds, even though early breastfeeding did not occur, such as with premature infants.

The maternal bond according infant attachment researcher James Robertson, from his 1982 book *A Baby in the Family: Loving and being Loved,* is defined such that: 'bonding does not refer to mutual affection between a baby and an adult but to the phenomenon whereby adults become committed by a one-way flow of concern and affection to children for whom they have cared for during the first months and years of life.'[15] In modern terms, we now know that this statement is incorrect, i.e. it is actually a two-way flow between the baby and the mother; they each get

something out of the bond, the mother psychological happiness and the baby stability to grow.[16] The maternal bond, according the 1982 views of Marshall Klaus and John Kennell, is defined such that 'the characteristics of the bonding process are not precise or uniform and do not in any way resemble the adhesive properties of the new, rapidly-acting glues.'[17] In 1998 they define a bond as an emotional connection of the mother to her infant.[18]

The function of bonding behaviors is to maintain proximity of the mother to her infant.[19] Originally, bonding theorists argued that, for an optimal bond to develop, physical contact between the mother and infant must occur early in the postpartum period.[14] It is at this particular time when maternal oxytocin circulation, as a component of labor, is at its peak, and some research has shown that at times when central oxytocin levels are high in women, they are predisposed to form bonds and display affiliative behavior.[20] Numerous studies in nonhuman animals have shown that maternal behavior can be mediated by the peptide hormone, yet these findings have not been replicated consistently in human mothers.[21]





A new mother breast feeding and new fathers walking their children: activities that tends to strengthen the maternal or paternal bond.

Paternal bond

In contrast to the maternal bond, in terms of variation in strength and stability, the *father-infant bond* or 'paternal bond' tends to vary greatly over the lifespan of a child's development and growth and in many cases does not exist. Many children, for example, in modern times, grow up in fatherless households. In general, paternal bonding is more dominant later in a child's life after language develops. Father-child bonds tend to develop with respect to topics and areas such as political views or money; whereas mother-child bonds tend to develop in relation to topics such as religious views or general outlooks on life.[22]

In nonhuman primates, the paternal bond, according to American sociologist and bonding researcher Anthony Walsh, is a protective function and is little more than a

generalized responsibility for all the young in the troop with no special emphasis for the protection of his own offspring.[9] In human fathers, according to Walsh, the paternal-offspring bond, derived from the intellectual knowledge of their paternity is a comparatively deeper bond. In addition, the paternal bond, like the maternal bond, depends on the prior establishment of affectional ties to others of the species during the father's own infancy and childhood.[9]

Comparatively, between the two parental attachment, the paternal bond is significantly weaker, or in many cases non-existent. The attachment is generally weak in the case of the paternal male child bond, but predominantly stronger in the case of the paternal female child bond.[22]

Studies over the last two decades have shown, in the transition to parenthood, that new fathers tend to distance themselves from the parental role during the infancy stage but take increasing interest as the child becomes older.[9] New fathers see the infant rather like a 'thing' rather than a new autonomous person who needs interaction. Only when the child becomes more autonomous and is able to react meaningfully, in the sense that the father understands the reaction, does the father take pleasure in his parental role.[9] In other words, the child begins to 'earn' the father's interest and love by displaying the various skills and attributes of which the father approves.[23]

To cite an example of neurochemical factors involved in the paternal bond, in 2003 researchers at Northwestern University in Illinois found that progesterone, a hormone more usually associated with pregnancy and maternal bonding, may also control the way men react towards their children. Specifically, they found that a lack of progesterone reduced aggressive behavior in male mice and stimulated them to act in a fatherly way towards their offspring.[24]

In general, men, in contrast to women, are driven in society to be occupationally successful and to achieve greatness. To this end, the focus of energy in the males catch of bonds will tend to be directed more so to achievement bonds than to infant or offspring bonds.

Sibling bond

The *sibling bond* is a powerful emotional connection between brothers and sisters throughout life.[25] The sibling bond is a distinctive emotional, passionate, painful, and solacing power that shapes who we are and who we become. The relationships among brothers and sisters are infinitely varied. A sibling can be one's worst enemy or closest companion. Though their love or hate, envy or compassion, and closeness or rivalry are formed in childhood, these bonds last throughout life, creating character and affecting behavior in numerous situations.

Strangely, until 1982, with the publication of Stephen Bank and Michael Kahn's book *Sibling Bond*, this profound attachment, second, some have argued, only to the

parent-child bond, was rarely studied or understood. They argue that before this period, the word 'sibling' was almost synonymous with 'rivalry', but that now it is defined as a distinctive emotional and passionate power that shapes who we are and who we become. They point out the curious and often-overlooked fact that 'the sibling relationship is life's longest lasting relationship, longer, for most of us by a quarter of a century, than our ties to our parents. It lasts longer than our relationship with our children, certainly longer than with a spouse, and, with the exception of a few lucky men and women, longer than with a best friend.'

Interestingly, they state that when they originally sat down to write their book in the early 1980s, that 'almost no one was talking about, and few people were more than casually interested in, the idea that siblings have a *bond*.' Resultantly, as they discovered, their 'research was a wake-up call to psychologists and psychotherapists, as well as to the university researchers who study child and adult development.' In fact, they helped to over turn the long-accepted idea that the parents are the principle molders of personality, where instead sibling bondings may have the more complex influence.

In 1995, building on the work Bank and Kahn, author Susan Merrell, in her book *Accidental Bond: the Power of Sibling Relationships*, argues that sibling relationships determined in childhood influence our lives in often unsuspected and startling ways. Moreover, no matter what kind of relationship we now have with our siblings, according to Merrell, our histories with them exert a profound effect on our current relationships with lovers, friends, coworkers, even our own children.[26] The dynamics of all sibling relationships, according to Merrell's psychoanalytic research, are a result of 'hidden forces that bring siblings together and push them apart'.

In sum, through the reaction evolution of the sibling bond, during its life course, siblings will attach or detach, create each other's identities, and often affect the course of each other's lives.

Grand-paternal bonding

In family life, *grand-paternal bond* is a distinctive, dynamic, and unique relationship between a grandparent and a grandchild. The grand-paternal relationship, according to recent demographics, has the potential to span three to four decades of life.[27] In this situation there will be a bonding dynamics relative to the older adult, the middle generation, and the grandchild, each with its own stabilities and behaviors. To give an estimate of the prominence of these bonds, in 1985, 11% percent of the population in the U.S. consisted of men and women 65 years and older, 70% of whom were grandparents. In 1979, the chances of a 10-year-old having at least two living grandparents was 50% and the chances of having three living grandparents was 38%; this can be compared to the year 1929 when the chances were 40 and 10%,

respectively.[28] Likewise, the average person can expect to spend nearly one-half of their life as a grandparent.[27]

The grandchild-grandparent bond, according to personal health writer Diane Griffith, whether the pair live a mile apart or are separated by several states, is 'a special bond exists between grandparents and grandchildren, in which the grandparents provide children with unconditional love and in return they get back what they give and more including healthier, happier, and more active lives.[29] In short, according to Griffith, grandparents teach children what they wouldn't learn anywhere else. Throughout their lives, children remember the skills, knowledge, values and attitudes that their grandparents pass down. Children who have strong relationships with grandparents tend to do better in school, have a stronger sense of family and feel more comfortable with older people than those who do not, and are less likely to become involved with drugs or violence.[29]

Likewise, according to writer Mary Alward, from her 2003 article 'Bonding with Grandparents', children often feel that a grandparent is someone who will listen to them, and accept what they do without question and in this manner function as an unbiased realistic gauge on their behavior or actions. Grandparents often appreciate everything that their grandchildren do, without being critical and in this sense they will relish the role. Grandparents will tend to bond to their grandchildren without taking on the role of disciplinarian and often function as a release valve for the many pressures in a child's life.[30] Studies have found that grown adults who had or have a close bond with their grandparents class themselves as lucky; whereas, grown adults who never experienced a relationship of any kind with grandparents feel that they've missed something in life.[30]

The state of each of the intergenerational ties, according to research, depends on a grandparent's perception of their own grandparents, their parents' attitudes toward grandparent, and the stereotypes of grandparents created by society and media at the time.[31] The function of the grand-paternal bond and its derivatives is several fold, namely (1) to provide a secondary stability platform for the evolving child, different from that of the paternal-platform, (2) as a stability gauge for the newly discerning child, adolescent to teenage, to use as an estimate of the future, and to regulate his or her speed accordingly, depending on if that future picture looks bright or tenebrous, and (3) to function as an anchor point holding the various extended families in place.

Attachment

In attachment theory psychology, *attachment* is a product of the activity of a number of behavioral systems that have proximity to a person, e.g. a mother, as a predictable outcome.[32] The concept of there being an 'attachment' behavior, stage, and process, to which a growing person remains in proximity to another was developed beginning in 1956 by British developmental psychologist John Bowlby. The concept of

proximity attachment, according to Bowlby has its origins in Charles Darwin's 1856 *Origin of Species*, which according to Bowlby 'sees instinctive behavior as the outcome of behavioral structures that are activated by certain conditions and terminated by other conditions', Sigmund Freud's 1905 *Three Essays on the Theory of Sexuality* and his 1915 *Instinct and Their Vicissitudes*, which according to Bowlby 'postulates part-instincts, differentiates the aim of an instinct, namely the conditions that terminate instinctive behavior, and its function, and notes how labile are the objects towards which any particular sort of instinctive behavior is directed', and Konrad Lorenz's 1937 theory of imprinting.[33]

In this sense, when thinking about the word attachment as compared to the word bonding, a good rule of thumb is visualize a string of goslings 'attaching' to the sight of Lorenz's black wadding boots and staying in proximity to that visual. In human terms, a newborn will attach onto the sight, sound, touch, taste, and smell of their mother. In adult terms, friends, associates, and mates will often 'attach' onto select people or stimuli in a similar manner. Bonding, then, as contrasted with this will be more of a two-way flow in adhesion dynamics. Conversely, according to the 1995 edition of Klaus, Kennell, and Klaus' *Bonding*, psychologists have the opinion that 'by general consensus, the term bonding refers to the tie from parent to infant, whereas the word attachment refers to the tie from infant to parent' and that 'the word attachment in its more generally understood meaning, [refers] to the feelings that bind one person to another, in either direction.' This over-focus on words here, to note, has to do with the fact that attachment theory originated first, whereas bonding is the correct term to use from the chemical point of view.

To clarify further, according to a review of recent publications, many seem to be hung up on the distinction between the words 'tie', 'attachment', and bond'. Each of these, however, is simply a variation of a human chemical bond. The names are only labels to a bonding processes that can be categorized. The over-prominence of the word 'attachment' stems from Bowlby. In the 1960s, according to his son Richard Bowlby, 'my father was very careful to avoid having his name linked to it and he asked the family one supper time what he should call it?' His preference, according to Richard, was for 'attachment theory' because he no longer liked 'child's tie to his mother'. In reply, the family returned with 'why don't you call it *love theory*? He replied that 'love was far more complex than this very specific biological protection mechanism that he was working on.'[34]

In any event, the use of either term, i.e. tie, attachment, bond, etc., will depend on context. Bowlby, for instance, argues that the fundamental dynamics of the attachment relationship is that the infant is active in seeking interaction, that the mother's maternal behavior is reciprocal to the infant's attachment behavior, and that the development of attachment is related to both to the sensitivity of the mother in responding to her baby's cues and to the amount and nature of their interaction.[33] In short, Bowlby defines basic attachment dynamics as 'reciprocal interchange'.

In recent years, although the term 'attachment' is still used in many areas of study, e.g. attachment in children, attachment in adults, reactive attachment disorder, etc., the more chemically-correct term 'bonding' is slowly beginning to replace the latter.[35] The 2001 book *The Ontogeny of Human Bonding Systems* by American transactional psychologists Warren Miller and Joseph Rodgers, for instance, is a modern-day spin-off of Bowlby's Part IV: *Ontogeny of Human Attachment* in Volume I of his three-volume Attachment series books.

Originally, in 1958, Bowlby had published the paper 'the Nature of the Child's Tie to his Mother', in which the precursory concepts of *attachment* were developed. This later led to the development of the concept of the 'affectional bond', sometimes referred to as the *emotional bond*, which is based on the universal tendency for humans to attach, i.e. to seek closeness to another person and to feel secure when that person is present. Attachment theory has its origins in the observation of and experiments with animals. Much of the early research on attachment in humans was done by John Bowlby and his associates. Bowlby proposed that babies have an inbuilt need from birth to make emotional attachments, i.e. bonds, because this increases the chances of survival by ensuring that they receive the care they need.[36]

Bowlby's decisive conception of the existence of psychological ties, bonds, or 'attachments' between humans, to note, is the most thoroughly conceived theory of human dynamic psychological bonding to date. Between his three-volume set on attachment, i.e. *Attachment,* Vol. 1 (1969), *Separation and Anxiety and Anger,* Vol. 2 (1973), *Loss: Sadness and Depression,* Vol. 3 (1980), and other books such as his *The Making and Breaking of Affectional Bonds* (1979), Bowlby has successfully written over 1,000 pages of theory about human bonding and debonding. To these path-breaking efforts, we commend him.

The major crux of downfall, however, in his entire theoretical edifice is that he disparages Freud for his use of the laws of thermodynamics in the development of theory. Bowlby declares that the laws of thermodynamics are outdated and not at all applicable or useful in psychology and in fact there use is a 'barrier' to the successful 'integration of psychoanalysis with present-day science'.[37] He specifically states that in attachment theory, 'the points of view not adopted are the *dynamic* (psychological forces) and the *economic* (psychological energy); there are therefore no propositions concerning psychological energy or psychological forces; concepts such as conservation of energy, entropy, direction and magnitude of force are all missing.' To worsen the matter further, he incorrectly states 'nor is it supposed that the principle of entropy applies to living as it does to non-living systems'.[37]

He could not be more wrong. As noted English astrophysicist Arthur Eddington famously put it to everyone in his quote-filled 1928 book *The Nature of the Physical World*, 'the law the entropy always increases—the second law of thermodynamics—holds the supreme position among the laws of nature. If someone points out that your pet theory of the universe is in disagreement with Maxwell's equations—then

so much the worse for Maxwell's equations. If it is found to be contradicted by observation—well, these experimentalists do bungle things sometimes. But if your theory is found to be against the second law of thermodynamics I can give you no hope; there is nothing for it but to collapse in deepest humiliation.'[38]

There is no doubt that Bowlby, by virtue of his statements, humiliated his near-perfect theory of attachment with his off arguments to discredit the second law of thermodynamics. He does, however, to his defense, state that 'these, it is realized, are large claims and may not be readily acceptable'. In any event, he spends the entire first chapter of his paramount 1969 *Attachment Theory* book trying to beat Freud's thermodynamical psychology theories into the ground. It is puzzling why he would go to such efforts to discredit Freud and the laws of thermodynamics in this manner? It is likely, possibly, that he was making efforts to avoid what did not understand or was confused about.

To note, however, Bowlby does adopt many of Freud's basic theories, e.g. his hypothesis that trauma results when the mental apparatus is subjected to excessive quantities of excitation, but in any event seems to have great issues with Freud's thermodynamic theories, particularly that of motivation. Specifically, Bowlby states that there are features of his approach that do differ from Freud's. Namely, 'of these by far the main one concerns the *theory of motivation*.' In addition, 'since these theories that Freud advanced regarding drive and instinct are the heart of psychoanalytic meta-psychology, whenever an analyst departs from them it is apt to cause bewilderment or even consternation.'

Another peculiarity here, to note, is that Freud and Bowlby were both looking at the energetics of psychological processes from different points of view. Freud, for the most part, viewed the *dura mater*, i.e. the tough fibrous membrane that envelops the brain and the spinal cord, to be his thermodynamic system boundary and sought to understand energetic displacements within this system, whereas Bowlby, on the other hand, viewed the orbital boundary of the movements of the parent-infant dyad to be his energetic boundary of study and sought to understand displacements of individuals within his system boundary and the emotional and sensory exchanges that cause these movement displacements. Beyond this, most people have a difficult time with thermodynamics, let alone trying to apply it to psychology.

Many of Freud's thermodynamic psychology theories themselves, to note, are not perfect in their exact formulations either, but to throw Freud's early dynamic psychological models out the window, was a poor choice. At this point, it would be too lengthy of a discussion to go into the details of what needs to be cleaned up in both of these models, but let us state clearly and exactly here that any rigorous model of the psychology of life will always begin with the laws of thermodynamics and build upwards. The paramount fact-of-life and psychology is that heat flows into the earth system and drives evolution and that the laws of thermodynamics define this chemical reaction process.

To elaborate on this life-encompassing heat fundamental, in the famous words of Albert Einstein 'a theory is more impressive the greater is the simplicity of its premises, the more different are the things it relates, and the more extended its range of applicability. Therefore, the deep impression which *classical thermodynamics* made on me. It is the only physical theory of universal content which I am convinced, that within the framework of applicability of its basic concepts will never be overthrown.'[40]

Similarly, according to Russian thermodynamicist Ivan Bazarov, 'the second law of thermodynamics is, without a doubt, one of the most perfect laws in physics. Any *reproducible* violation of it, however small, would bring the discoverer great riches as well as a trip to Stockholm. The world's energy problems would be solved at one stroke. It is not possible to find any other law (except, perhaps, for super selection rules such as charge conservation) for which a proposed violation would bring more skepticism than this one. Not even Maxwell's laws of electricity or Newton's law of gravitation are so sacrosanct, for each has measurable corrections coming from quantum effects or general relativity. The law has caught the attention of poets and philosophers and has been called the greatest scientific achievement of the nineteenth century.'[41]

Interestingly, Bowlby cites the biologists as being the ones to have abolished the use of the laws of thermodynamics in living systems and operations. This, however, is not the case. According to the views of American biophysicist Donald Haynie, from his 2001 textbook *Biological Thermodynamics*:

> "Any theory claiming to describe how organisms originate and continue to exist by natural causes must be compatible with the first and second laws of thermodynamics."

In any event, to sum things up, Bowlby's bonding theories are good, but his views on the un-need use of thermodynamics in psychology are wrong.

Nevertheless, to give an basic example of how attachment theory is currently used, in the late 1980s relationship psychology researchers Cindy Hazan and Phillip Shaver began to apply attachment theory to adult romantic relationships.[42] Hazan and Shaver noticed that interactions between adult romantic partners shared similarities to interactions between children and caregivers. Romantic partners, for instance, desire to be close to one another. Romantic partners feel comforted when their partners are present and anxious or lonely when their partners are absent. Romantic relationships often serve as a secure base, that help partners face the surprises, opportunities, and challenges life presents. Similarities such as these led Hazan and Shaver to extend attachment theory to adult romantic relationships.[43]

In the 1990s, researcher began to study the psychobiology of attachment.[44] In 2001, to cite one example, American neurobiologist Allan Schore, a pioneer in the field of *affective neuroscience*, i.e. the study of the neural mechanisms of emotion, states that 'over the last ten years the basic knowledge of brain structure and function has vastly expanded.' He argues that underlying neurobiology of any secure attachment, involves adaptive infant mental health, a focus upon the primary caregivers psychobiological regulation of the infant's maturing limbic system, and the brain areas specialized for adapting to a rapidly changing environment.[45] The infant's early developing right hemisphere, according to Schore's research, has deep connections into the limbic and autonomic nervous systems and is dominant for the human stress response, and in this manner the attachment relationship facilitates the expansion of the child's coping capacities. His neuro-biological attachment models suggest that adaptive infant mental health can be fundamentally defined as the earliest expression of flexible strategies for coping with the novelty and stress that is inherent in human interactions. This efficient right brain function is thus a resilience factor for optimal development over the later stages of the life cycle.[45]

Affectional bond

In psychology, the term *affectional bond* is a type of attachment behavior one individual has for another individual, typically a mother for her child, in which the two partners tend to remain in proximity to one another.[46] The term was coined and subsequently developed over the course of four decades, from the early 1940s to the late 1970s, by psychologist John Bowlby in his work on attachment theory. The core of the term 'affectional bond', according to Bowlby, is the attraction one individual has for another individual. The central features of the concept of affectional bonding can be traced to Bowlby's 1958 paper 'the Nature of the Child's Tie to his Mother.'[47] To exemplify, Bowlby stated that he had an affectional bond at age four to his nanny named Minnie.[46]

Bowlby referred to attachment bonds as a specific type of a larger class of bonds that he and developmental psychologist Mary Ainsworth described as *affectional* bonds. Ainsworth established five criteria for affectional bonds between individuals, and a sixth criterion for attachment bonds:

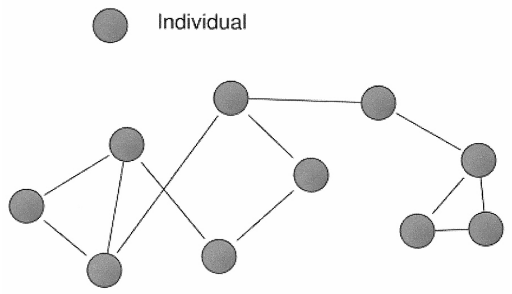
1. An affectional bond is persistent, not transitory.
2. An affectional bond involves a particular person who is not interchangeable with anyone else.
3. An affectional bond involves a relationship that is emotionally significant.
4. The individual wishes to maintain proximity or contact with the person with whom he or she has an affectional tie.
5. The individual feels sadness or distress at involuntary separation from the person.

The affectional bond, according to Bowlby, begins as a child's tie to his mother as an instinct that starts in infancy and then evolves throughout life as people grow up, and become part of the adult dynamics of love, hate, and ambivalence. To clarify, we clearly note that hate is always part of the mixture, no matter what the bond. Hatred, in small amounts, is what keeps the bond or relationship from imploding inward. Too much bonding hatred, however, will lead to complete and total separation.

Bowlby was well aware of this 'inconvenient tendency', as he calls it, of hate or ambivalence in bonds. Methods of child care, for instance, in the effects, beneficial or adverse, that it has on a child's developing capacity to regulate the conflict of love and hate, according to Bowlby, will relate to a child's 'capacity to experience in a healthy way his anxiety and guilt.' The affectional bond operates in our early years by the effects of impelling feelings of 'anger and hatred as well as concern and love' towards both one's siblings and one's parents.[46] A true affectional bond, according to Bowlby, will have the additional criterion that the person seeks security and comfort in the relationship.

Interpersonal ties

In mathematical sociology, *interpersonal ties* are defined as information-carrying connections between people.[48] Interpersonal ties, generally, come in three varieties: *strong*, *weak*, or *absent*. Weak social ties, it is argued, are responsible the majority of the matrix embeddedness and structure of social networks in society as well as the transmission of information through these networks.[49] Specifically, more novel information flows to individuals through weak than through strong ties. Because close friends tend to move in similar circles, the information they receive overlaps considerably with what a person already knows. Acquaintances, by contrast, know what one does not know, and thus contains more novel information.[50]



Nodes (individuals) and **ties** (connections) in social networks.

One the of the earliest writers to discuss the effects of ties between people was the German scientist and philosopher Johann von Goethe, where in his classic 1809 novella *Elective Affinities* speaks of the *marriage tie* and by analogy shows how

strong marriage unions are similar in character to that by which the particles of quicksilver find a unity together though the process of chemical affinity.[51]

In 1954, the Russian mathematical psychologist Anatol Rapoport commented on the 'well-known fact that the likely contacts of two individuals who are closely acquainted tend to be more overlapping than those of two arbitrarily selected individuals.'[52] This argument became one of the corner stones of the probabilistic approach to network theory. In 1973, stimulated by the work of Rapoport, American sociologist Mark Granovetter published *The Strength of the Weak Ties*, which is recognized as one of the most influential sociology papers ever written.[53] In the late 1960s, a series of lectures by Harvard social network theorist Harrison White had exposed Granovetter to the concept of social networks.[54] In this direction, to obtain data for his doctoral thesis, Granovetter interviewed dozens of people to find out how networks are used to land new jobs. Granovetter found that most jobs were found through *weak* acquaintances. This pattern reminded him of his freshman chemistry lesson demonstrating how *weak* hydrogen bonds hold huge water molecules together, which are themselves held together by *strong* covalent bonds.[55]

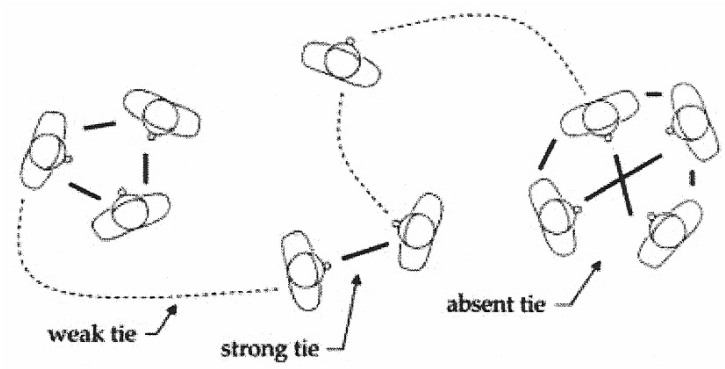
In chemistry, a *hydrogen bond* is a special type of dipole-dipole interaction between the hydrogen atom in a polar bond, such as N-H, O-H, or F-H, and an electronegative O, N, or F atom. These possible arrangements can be written as follows:[56]

A—H---B

or

A—H---A

where " — " is a strong *covalent bond* and " --- " is a weak *hydrogen bond*. Here, A and B represent the atoms *O*, *N*, or *F*; where A—H is one molecule or part of a molecule and B is a part of another molecule. In Granovetter's view, this was the basic model of society:[53]



Granovetter's 1969 weak ties model

This model became the basis of his first manuscript on the importance of weak social ties in human life. He mailed it out in August 1969 to the *American Sociological Review*. It was rejected, however, because, in the words of two anonymous referees, the manuscript should not be published for 'an endless series of reasons that immediately come to mind.' In 1972, nevertheless, Granovetter submitted a shortened version to the *American Journal of Sociology*, and it was finally published in May 1973. In the years to follow, the 'Weak Ties paper', according to Current Contents, by 1986, had become a citation classic, being one of the most cited papers in sociology.

Inclusive in the definition of *absent ties*, according to Granovetter, are those relationships (or ties) without substantial significance, such as *nodding* relationships between people living on the same street, or the *tie*, for example, to the vendor from whom one customarily buys a morning paper. Moreover, the fact that two people may know each other by name does not necessarily qualify the existence of a weak tie, e.g. if their interaction is negligible the tie may be of the absent variety. The *strength* of an interpersonal tie is a linear combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize each tie.[57]

In 1969, anthropologist Bruce Kapferer published his *Norms and the Manipulation of Relationships in a Work Context* based on recent fieldwork in Africa, in which he postulated the existence of *multiplex ties*, characterized by multiple contents in a relationship.[58] In other words, a multiplex tie carries more than one stream of information. In telecommunications, by comparison, a 'multiplexer' is a device that allows a transmission medium to carry a number of separate signals. In social relations, by extrapolation, 'multiplexity' is the overlap of roles, exchanges, or affiliations in a social relationship.[59]

To research the conception of weak ties, in Granovetter's original paper, he crossed the Charles River to Newton, Massachusetts where he surveyed 282 professional, technical, and managerial workers in total, of which 100 were personally interviewed, in regards to the type of tie between the job changer and the contact person who provided the necessary information. Tie strength was measured in terms of how often they saw the contact person during the period of the job transition, using the following assignment:

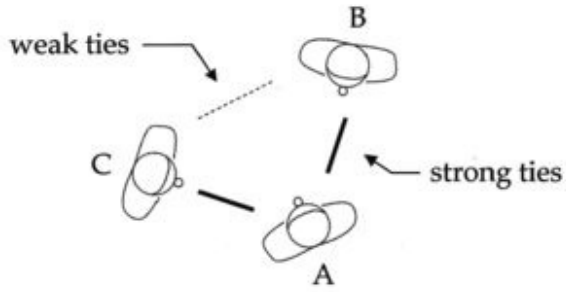
- **Often** = at least once a week.
- **Occasionally** = more than once a year but less than twice a week.
- **Rarely** = once a year or less.

Of those who found jobs through personal contacts (N=54), 16.7% reported seeing their contact often, 55.6% reported seeing their contact occasionally, and 27.8% rarely.[60] When asked whether a friend had told them about their current job, the most frequent answer was 'not a friend, an acquaintance.' The conclusion from this study

is that weak ties are an important resource in occupational mobility. When seen from a macro point of view, weak ties play a role in effecting social cohesion.

In social network theory, social relationships are viewed in terms of *nodes* and *ties*. Nodes are the individual actors (human molecules) within the networks, and ties are the relationships (chemical bonds) between the actors. There can be many kinds of ties between the nodes. In its most simple form, a social network is a map of all of the relevant ties between the nodes being studied.

Based on Granovetter's findings and using a combination of probability and mathematics, as originally stated by Anatol Rapoport in 1957, the basic *weak tie hypothesis* argues that if A is linked to both B and C, then there is a greater than chance probability that B and C are linked to each other:[61]



Weak tie hypothesis diagram

That is, if we consider any two randomly selected individuals, such as A and B, from the set S = A, B, C, D, E, ..., of all persons with ties to either or both of them, then, for example, if A is strongly tied to both B and C, then according to probability arguments, the *B-C tie* is always present. The absence of the *B-C tie*, in this situation, would create, according to Granovetter, what is called the *forbidden triad*. In other words, the *B-C tie*, according to this logic, is always present, whether weak or strong, given the other two strong ties. In this direction, the weak tie hypothesis postulates that clumps or cliques of social structure will form, being bound predominately by *strong ties*, and that *weak ties* will function as the crucial bridge between any two densely knit clumps of close friends.[62]

It follows, then, that individuals with few weak ties will be deprived of information from distant parts of the social system and will be confined to the provincial news and views of their close friends. From this basis, other theories can be formulated and tested, e.g. that the diffusion of information, such as rumors, may tend to be dampened by strong ties, and thus flow more easily through weak ties.

Starting in the late 1940s, Anatol Rapoport and others developed a probabilistic approach to the characterization of large social networks in which the nodes are persons and the links are acquaintanceship. During these years, formulas were

derived that connected local parameters such as closure of contacts, such as the supposed existence of the *B-C tie*, to the global network property of connectivity.[61]

Moreover, acquaintanceship, in most cases, is a *positive tie*, but what about *negative ties* such as animosity among persons? To tackle this problem, graph theory, which is the mathematical study of abstract representations of networks of points and lines, can be extended to include these two types of links and thereby to create models that represent both positive and negative sentiment relations. This effort led to an important and non-obvious *structure theorem*, as developed by Dorwin Cartwright and Frank Harary in 1956, which says that if a network of interrelated positive and negative ties is balanced, e.g. as illustrated by the psychological consistency of 'my friend's enemy is my enemy', then it consists of two subnetworks such that each has positive ties among its nodes and negative ties between nodes in distinct subnetworks.[63] The imagery here is of a social system that splits into two cliques. There is, however, a special case where one of the two subnetworks may be empty, which might occur in very small networks.

In these two developments, we have mathematical models bearing upon the analysis of structure. Other early influential developments in mathematical sociology pertained to process. In 1952, for instance, American systems theorist Herbert Simon produced a mathematical formalization of a published theory of social groups by constructing a model consisting of a deterministic system of differential equations.[64] A formal study of the system led to theorems about the dynamics and the implied 'equilibrium states' of any group.

In the early 1990s, American social economist James Montgomery contributed to economic theories of network structures in labor market.[65] In 1991, Montgomery incorporated network structures in an adverse selection model to analyze the effects of social networks on labor market outcomes.[66] In 1992, Montgomery explored the role of 'weak ties', which he defined as non-frequent and transitory social relations, in labor market.[67] He demonstrates that weak ties are positively related to higher wages and higher aggregate employment rates.

In sum, weak social ties, or *weak ties*, it is argued, are responsible for the majority of the embeddedness and structure of social networks in society as well as the transmission of information through these networks. Specifically, more novel information flows to individuals through weak than through strong ties. Because our close friends tend to move in the same circles that we do, the information they receive overlaps considerably with what we already know. Acquaintances, by contrast, know people that we do not, and thus receive more novel information.[68]

Limerent bond

In relationship science, a *limerent bond* that associated with an involuntary cognitive and emotional state in which a person feels an intense romantic desire for another person (the limerent object).[69] *Limerence* is a term, coined in 1977 by psychologist Dorothy Tennov, which characterizes a 'state of love' personified by a blending of passion, intrusive thinking, longing, uncertainty, and hope. The concept of limerence stems from Tennov's research, beginning in the mid 60s, in which she interviewed, questioned, and surveyed over 500 people on the topic of romantic love. In doing so, she set out to understand and to quantify that variety of passionate love as described in Stendhal's 1822 classic *On Love*, where one is infatuated with another, but where the love is not reciprocated.[70]

Regarding the etymology of the word 'limerence', Tennov, while a professor of psychology at the University of Bridgeport, Connecticut, coined the term *limerence* in 1977, and first published it in her 1979 book *Love and Limerence: The Experience of Being in Love*. The word was pronounceable and seemed to her and two of her students to have a fitting sound. Speculatively, the word limerence is a combination of the word *love* and Irish word *Limerick*, i.e. a short humorous verse that is often nonsensical and frequently ribald, conjoined with the suffix *–ence*, meaning a 'state' or 'process'. Hence, *limerence* may describe a coarse yet comical process of love that many go through. The word is not found in current dictionaries, but is nevertheless in use by psychologists and by others discussing romantic relationships.

To elaborate, according to limerence theory a certain percentage of couples may go through what is called a *limerent reaction*, in which one or both of the pair may experience a state of passion mixed with continuous intrusive thinking, fear of rejection, and hope. Hence, with all limerent human romantic relationships, one of three varieties of *bonds* may form, defined over a set duration of time, in relation to the experience or non-experience of limerence:[70]

1. **Affectional bond:** define relationships in which neither partner is limerent.
2. **Limerent-Nonlimerent bond:** define relationships in which one partner is limerent.
3. **Limerent-Limerent bond:** define relationships in which both partners are limerent.

In sum, once the limerent reaction has initiated, one of three varieties of bonds may form, defined over a set duration of time, in relation to the experience or non-experience of limerence. The constitution of these bonds may vary over the course of the relationship, in ways that may either increase or decrease the intensity of the limerence.

Affectional bonding, according to Tennov, characterize those affectionate sexual relationships where neither partner is limerent; couples tend to be in love, but do not report continuous and unwanted intrusive thinking, feeling intense need for exclusivity, or define their goals in terms of reciprocity. These types of bonded

couples tend to emphasize compatibility of interests, mutual preferences in leisure activities, ability to work together, and in some cases a degree of relative contentment. The bulk of relationships, however, according to Tennov, are those between a limerent person and a nonlimerent other, i.e. *limerent-nonlimerent bonding*. These bonds are characterized by unequal reciprocation. Lastly, those relationship bonds in which there exists mutual reciprocation are defined as *limerent-limerent bondings*.

Limerent bonds are also characterized by entropy 'crystallization' as described by Stendhal in his 1821 treatise *On Love*, where a new love infatuation perceptually begins to transform visually into a prince or princess. This is discussed further in the following chapter.

Tennov argues since limerence itself is an 'unstable state' that mutually limerent bonds would be expected to be short-lived; mixed relationships probably last longer than limerent-limerent relationships; and affectional bondings tend to be characterized as 'old marrieds' whose interactions are typically both stable and mutually gratifying. Since Tennov, however, only interviewed one member of the bonded pair during her research, these predictions remain tentative.[71]

Erotic bond

In sexuality research, an *erotic bond* is an attachment to someone who matches an idealized mental lovemap, i.e. a bonding to someone who matches a developmental representation or template in the mind and in the brain depicting the idealized lover and the idealized program of sexuoerotic activity projected in imagery or actually engaged in with that lover.[72] In short, an 'erotic bond' is a sexual attachment to a person who matches one's sexual fantasies.

In the 1988 book *Love Maps*, psychologist John Money postulated the existence of the 'erotic bond' in which each person is theorized to have a correlative *lovemap* based on his or her upbringing and experiences. A love map may make note of both positive and negative factors, things that attract or repel the person whose erotic tastes are being mapped. For reasons that are not always easy to understand, one person may be attracted to people of a particular gender, people with particular physical characteristics, such as hair color, people with particular personality traits, e.g. a sardonic sense of humor, etc. One may also find certain characteristics so threatening or objectionable (again, for reasons that may be difficult or impossible to ascertain) that it strongly mitigates against an erotic attraction being manifested. Using one's love map, a person unconsciously makes note of the personal and environmental factors that facilitate the formation of an erotic bond.[72]

A lovemap can be shaped by environmental factors that facilitate the formation of an erotic bond, or that enhance or diminish erotic response. Some people, for instance, may bond strongly to people with whom they share a crisis situation. Some

people may find their erotic responses muted in the presence of intimidating environmental factors, e.g. observant elders or nosy neighbors.

The word *lovemap*, according to Money, was first used in a 1980 article titled 'Pairbonding and Limerence'. Before this time, interestingly, Money had begun to talk about lovemaps, in precursory form, with his students in lectures. The seed for this concept can be found in his 1980 book *Love and Lovesickness: the Science of Sex, Gender Difference and Pairbonding,* where he states:[73]

> "There is a rather sophisticated riddle about what a boyfriend (or girlfriend) and a Rorschach inkblot have in common. The answer is that you project an image of your own onto each. In many instance, a person does not fall in love with a partner, per se, but with a partner as a Rorschach love-blot. That is to say, the person projects onto the partner an idealized and highly idiosyncratic image that diverges from the image of that partner as perceived by other people. Hence the popular idiom that love is blind, for a lover projects onto a partner, or love-blot, his/her unique love image, as unique as his/her own face or finger print."

Like the acquirement of a native language, a person's lovemap also bears the mark of his or her own unique individuality, or accent. A lovemap is usually quite specific as to details of the physiognomy, build, race, and color of the ideal lover, not to mention temperament, manner, etc. Since its inception, the concept of 'love maps', applied to interpersonal relationships, has found apt acceptance and is frequently referenced in love, relationship, or sexual-evolution theory books; as for example in Wilson and McLaughlin's 2001 *The Science of Love*.[74]

To give an idea of some of the more far-reaching lovemaps and erotic bondings that can often occur, below are some examples out of the numerous variations found in clinical practice:

- **Heterosexual lovemaps** – love mapping pairings associative to the average or typical sexual relationships.
- **Vandalized lovemaps** – when the love mapping process or neurological template development stage becomes traumatized, as in for example being exposed at a young age, typically five to eight, to the sights, sounds and tortures of paraphilic sadist or masochist parents; or as in being led into a pedophilic relationship; or as being involved in an incestuous relationship.
- **Paraphilic lovemaps** – when lust is attached to fantasies and practices that are socially forbidden, disapproved, ridiculed, or penalized; sometimes as a result of birth deformity

(micropenis), chromosomal abnormality (45, X/46, XY), or as in accelerated growth (premature puberty).

- **Native lovemaps** - by analogy with native language, is a lovemap that is assimilated as one's own personal, inalienable possession, regardless of how many of its attributes are shared, or not shared by others.
- **Klismaphilic lovemaps** – specifies both in fantasy and performance that the person's sexuoeroticism will be aroused, and orgasm achieved, only if the partner participates in a scenario of administering an enema.
- **Acrotomophilic lovemaps** – specifies a paraphilia of the stigmatic/eligibilic type in which sexuoerotic arousal and facilitation of attainment of orgasm are responsive to, and dependent upon a partner who is an amputee, or in extreme cases a thalidomide baby who has reached adulthood.
- **Zoophilic lovemaps** – specifies a paraphilia of the stigmatic/eligibilic type in which sexuoerotic arousal and facilitation of attainment of orgasm are responsive to, and dependent upon engaging in cross-species sexual activities, that is, with an animal.

A lovemap, according to Money, is not something present at birth; rather it is like a native language, it differentiates within a few years thereafter. It and the bonds that result from it are, according to Money, 'a developmental representation or template in one's mind and is dependent on input through the special senses … it depicts your idealized lover and what, as a pair, you do together in the idealized, romantic, erotic, and sexualized relationship.' A lovemap first exists as mental imagery, in dreams and fantasies, and then translates into action with a partner or partners. This dynamic action constitutes the lovemap bond.

Money notes that pairbonding often begins at a young age. At around the age of eight, according to Money, 'two partners in sexual rehearsal play may become pair-bonded in a love affair that may be defined as a pairbonding rehearsal.' Money also discusses *troopbonding*, e.g. in lions, elephants, gorillas, and chimpanzees, as well as *lovebonding*, i.e. 'imagery of erotic attraction and genital arousal that can be well-established at an early age'. Moreover, he uses interesting physics conceptions such as *bonding power*, i.e. the ability of the bond to produce an effect. To exemplify this, the loss of 'power' in a pairbond, may result due the failure of the idealized image of one's lover in a person's lovemap, e.g. when a couple grows older allowing age-dissynchrony to set in, i.e. where men and women age at different rates, to affect lovemap perception. Thus, a couple in midlife may lose 'bonding power' owing to evolved lovemap incongruencies.

Of all the bonding theorists, Money by far discusses some of the more eccentric bonding situations, such as defined above. A highly specific form of zoolphilia, for instance, according Money's psychological interviews, is *formicophilia* in which arousal and orgasm are dependent on the sensations produced by small creatures like snails, frogs, ants or other insects creeping, crawling, or nibbling the genitalia and perianal area, and the nipples. Other bonding curiosities include thalidomide-bonding fetishes, cross-species attachments, etc., and each tends to have interesting

and logical arguments behind their use, as Money describes in detail in his book. A person, for instance, that grows up mentally insecure in a mining town in which, due to happenstance, there happen to be a large number of amputees, may develop a very real visualization that a future erotic-emotional bond with an amputee will stabilize those mental insecurities and inconsistencies.

Beyond these exotic variations of erotic bonding, most will have the tendency to fixate certain traits, such as hair or eye color, body type, e.g. well-shaped gluteus muscles, personality, e.g. sociability, or mental acumen, e.g. high intelligence, etc., which Money characterizes via terms such as *smell-bonding*, *visual-bonding*, *parent-child bonding*, *lover-lover bonding*, *affectional bonding*, *sexuoerotic bonding*, *pairbonding imprinting*, *partner affiliations*, etc., to name a few.

Limbic bond

The *limbic bond* is mammalian connection regulated by the limbic system in which mutually synchronizing sensory exchange as bodily warmth, olfactory cues, vocal exchange, visual interactions, etc., function to keep ties or organizing sensory channels between bound individuals.

Early on, researchers had begun to speculate that the phenomenon of attachment resides in the brain. In 1967, for instance, attachment theoretician Mary Ainsworth stated that attachment is more than overt behavior; it is internal, 'being built into the nervous system, in the course and as a result of the infant's experience of his transactions with his mother.'[75] In 1969, attachment theory pioneer John Bowlby posited that within the central nervous system of the brain there are *control systems* that maintain a *dynamic equilibrium* of intensity states of spatial proximity of attached partners in a bond. He argued that these attachment systems are 'cognitive maps' in the brain, and are accessed 'to transmit, store, and manipulate information that helps making predictions as to how set-goals (of attachment) can be achieved.'[76] Its functions, according to Bowlby, must be associated with the organism's 'state of arousal', which results from the critical operations of the brain's *reticular formation* (stereotypical actions), and with the 'the appraisal of organismic states and situations of the *midbrain nuclei* (motor control), and the *limbic system* (emotional part).'[77] He also postulates that the *prefrontal lobes* (thinking part) may play a key role in the control system operation of the neurobiological attachment.[78]

By 1984, on Bowlby's suggestion, neuro-psychiatrists had begun to assign the limbic system as being the site of developmental changes associated with the rise of attachment behaviors.[79] Later research confirmed this point of view, noting that the growth period of seven to fifteen months is a neuro-phase of rapid myelination, i.e. growth of the insulation sheath that covers nerve fibers, which makes them transmit signals and information faster, and the maturation of the rapidly developing limbic and cortical association areas. The limbic areas of the cerebral cortex, in particular,

is anatomically mature at fifteen months.[80] Moreover, recent studies have shown that attachment experiences, such as face-to-face transactions of affect synchrony between caregiver and infant, directly influence the imprinting, the circuit wiring of the orbital prefrontal cortex, a corticolimbic area known to begin a major structural change at ten to twelve months and to complete a critical period of growth in the middle to end of the second year.[80]

Building on this logic, in 2000 American psychologists Thomas Lewis, Fari Amini, and Richard Lannon, developed an elegant theory of limbic bonding, in their popular book *A General Theory of Love*, which defines a bodily connection that is limbic in nature. They also refer to this bond as a 'mammalian bond' being that mammals in contrast to reptiles have a limbic system, which is why reptiles abandon their young after birth whereas mammals do not.

In the limbic bond, a mutually synchronizing sensory exchange as bodily warmth, olfactory cues, vocal exchange, visual interactions, etc., function to keep ties or organizing sensory channels between connected individuals. These ties or bonds function to regulate those associated persons. They define this design as an open-loop regulatory system; where, as they state, adults are social animals: they continue to require a *source of stabilization outside themselves*. The open loop design means that in some important ways, people cannot be stable on their own; stability means finding people who regulate you well and staying near them. Their bonding theory is very good and they are humorous in the writing as well, e.g. they state that 'neurotics build castles in the sky, while psychotics live in them, and psychiatrists collect the rent'.

Birth-order connections

A *birth-order connection* is the tendency for people to seek out and stably attach to mates of opposite or dissimilar birth order rather than like birth order.[81] One of the first theorists to suggest that birth order influences personality was Austrian psychologist Alfred Adler, a contemporary of Sigmund Freud and Carl Jung. He argued that birth order often can leave an indelible impression on the individual's style of life, which is a habitual way of dealing with the tasks of friendship, love, and work.[82] Other factors that may be equally influential are: parental attitudes; organ inferiority, illness, and disability; gender confusion; or social, economic and religious circumstances. Any overburdening factor may intensify normal inferiority feelings and lead to unconscious compensations or over-compensations, i.e. an extremely talented older or younger sibling. Other birth order factors to be considered include the spacing in years between siblings; the total number of children; and the changing circumstances of the parents over time. Adler suggested that birth order does not cause any direction of personality development, but it may be used by the individuals as a building brick for their freely chosen style of life and

fictional final goal. Many researchers, in attempting to prove or disprove the sole effects of birth order, cite the complexity of other influences.[82]

In 1980s, American psychologist Kevin Leman began to study behavior patterns in relation to birth order. He published the results of his findings in the 1985 book *The Birth Order Book,* in which he outlined how birth-order strongly determines who a person is, who he or she marries, what job a person chooses, as well as the kind of parent one becomes. In 2001, in his book *The Birth Order Connection,* Leman began to apply this same logic to show how opposites attract in matting patterns.

The basic pattern found is that like birth order pairings in marriages, i.e. first-born married to first-born, middle-born married to middle-born, last-born married to last-born, etc., will tend to be less stable. The theory is that two people born of similar birth order will share similar vices and that when two people with similar vices bond, they will drag each other down. Leman puts it like this 'if you put two drug dealers in the same house, you're begging for trouble or … if you've got two liars, two compulsive spenders, two compulsive eaters—whatever it is, two of them make the situation ten times worse.'[81] The best combination, according to Leman's bonding research is a first-born married to a last born, whereas the worst of all is the pairing of two only childs, who each will tend to have the characteristics of double-firstborns.

Beyond the simple matchings, the picture becomes more complicated. Gender, for example, plays a large role. A female first born with brothers and a male last born with sister is a good match, whereas a female last born with no brothers and a male last born with no sisters is a bad match. Likewise, if there are more than three siblings in the family, the pairing potentials become more elaborate. Similarly, if there is gap between births of more than five years, then the latter born will tend to behave as a firstborn. The middle-borns are more difficult to predict. Nevertheless, as one example, if a middle-born with first-born tendencies will pair well with a last born.[81] In sum, birth order is not the dominant factor in pair-bonding, but it is a factor and in many cases can lead to the downfall of a good relationship.

Stepchild bonding

The *stepchild bond* is a relationship between a non-blood parent or parental figure and an attached child by marriage. In 2001, clinical psychologist Suzen Ziegahn, in her book *7 Steps to Bonding with Your Stepchild*, looked into the nuances of these types of bonds in which people 'inherit' children along with a new spouse. She finds that activities such as sharing a bathroom to initiating conversations can result in a long-lasting, rewarding relationship with a new attached family adult and a new child. Ziegahn points out that newly attached parents often feel caught in a bind between trying to connect with their stepchild, but not too much, too little, or too deliberately. Moreover, these relationships with stepchildren are inherently different

from those with biological children who love their parent unconditionally. The success or failure of a stepparent to bond with stepchildren, according to Ziegahn, can make or break a new marriage.[83]

In recent years, online sites, such as adopting.org, have begun to offer guidance and support to help stepparents bond to their newly attached children and how to deal with the common problem of rejection, i.e. where the child does not wish to bond with them.[84] Common internal questions that arise in these types of situations include: who *are* these strangers in my house? *Was* it my house?, etc., and part of making the transition and commitment to step-parenting, according to some researchers, involves making a firm attempt to know each step-kid individually, and apart from your mate.[85]

Type matching

In mate bonding theory, *type matching* is where a person with a certain personality type, e.g. introvert, extrovert, explorer, negotiator, director, builder, etc., is pair matched or bond-aligned to another person with a complementary type. There are many variations of type matching, e.g. matching two people with similar political views is an example of type matching.

At the pair-matching site *chemistry.com*, for example, which is based on the logic of the 2004 book *Why We Love – the Nature and Chemistry of Romantic Love*, pairs are matched to each other based on their characteristic type of dominant neurochemical. We know, for example, facts such as when testosterone washes over the brain in the womb, it builds aspects of personality and lengthens the fourth finger.[86] Thus, online, a good question they ask a person is to measure the fingers on their right hand, thus allowing a computer algorithm to obtain what is called a 'digit ratio', i.e. the length of one's second finger (pointing finger) as opposed to their fourth finger (ring finger). This ratio can indicate several aspects of personality, including the degree to which one is, by nature, assertive, verbal, musical, analytical and systematizing.

In addition, Fisher distinguishes between four personality types each of which she associates with a body chemical: *explorer* (dopamine), *negotiator* (estrogen), *director* (testosterone), and *builder* (serotonin). Specific personality traits, according to Fisher, correlate to increased hormonal activity in the brain. Increased dopamine levels, for example, are linked to risk taking, spontaneity and optimism, while high serotonin activity correlates to loyalty, conscientiousness and calmness. A high level of estrogen, in males or females, is associated with imagination, verbal ability and idealism; and testosterone relates to rationality, inventiveness and directness.[87]

Along these lines, at *Chemistry.com*, Fisher has designed an interactive online test to enable users to identify their own levels of each of these four body chemicals: two hormones (testosterone and estrogen) and two neurotransmitters (serotonin and

dopamine). One question, for example, is to ask if a person has a tendency to count things around them, such as books, stairs, or flower petals. Counters tend to have higher levels of dopamine and can be categorized as the explorer type. In a similar manner, people who experience déjà vu frequently, according to Fisher, tend to have higher estrogen levels in the brain and can be categorized as negotiators.

Once a person's neurochemical type is determined, people with high levels of estrogen (negotiators) can be matched with those who have increased levels of testosterone (directors). In the same way, Fisher says, explorers with elevated dopamine activity are well matched with builders who have increased serotonin activity. The two are balancing each other out, and the personalities not only fall in love, but stay in love, because they're enough different from each other to remain alluring and attractive, she says.[87]

Fluid bond

The recently STD-related term *fluid-bonding* is the process in which both partners agree not to exchange fluids (other than saliva) with anyone for six months.[88] At the end of six months each gets a full gauntlet including AIDS testing. If both are clean, the pair is then free to exchange fluids with the other person and the pair is then defined to be 'fluid-bonded'.

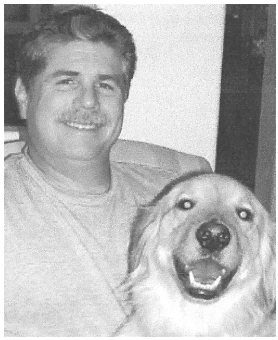
The usual motivating factor is greater enjoyment of sex without barriers, latex or otherwise.[89] Since fluid exposure is a conduit for STDs, by taking part in fluid bonding, participants are effectively trusting their sexual partners with their health. Ruling out sex or requiring strict protective behavior with any third partners is a common strategy for safety. The risks of belonging to a fluid-bonded group rise with the size of that group.

Where there are exactly two fluid bonded partners, the term *fluid monogamy* is used. However, larger groups of people have been known to take part in fluid-bonded polyamorous relationships.

Human-animal bond

The *human-animal bond* is a connection between people and animals, domestic or wild; be it a cat as a pet or birds outside one's window. Research into the nature and merit of the human animal bond began in the late 1700s when, in York, England, the Society of Friends established *The Retreat* to provide humane treatment for the mentally ill. By having patients care for the many farm animals on the estate, society officials theorized that the combination of animal contact plus productive work would facilitate the patients' rehabilitation. In the 1870s in Paris, a French surgeon had patients with neurological disorders ride horses. The patients were found to have

improved their motor control and balance and were less likely to suffer bouts of depression.[90]



Human-animal bond - human to animal contact is known to reduce the physiological characteristics of stress.

In the 19th century, in Bielefeld, Germany, epileptic patients were given the prescription to spend time each day taking care of cats and dogs. The contact with the animals was found to reduce the occurrence of seizures. In 1980, a team of scientists at the University of Pennsylvania found that human to animal contact was found to reduce the physiological characteristics of stress; specifically, lowered levels of blood pressure, heart rate, respiratory rate, anxiety, and tension were all found to correlated positively with human pet bonding.[90]

Historically, animals were domesticated for functional use; for example, dogs for herding and tracking, and cats for killing mice or rats. Today, in Western societies, their function is primarily a bonding function. Current studies, for instance, show that 60-80% of dogs sleep with their owners at night in the bedroom, either in or on the bed.[91] Moreover, in the past the majority of cats were kept outside (tomcats) whereas today most cats are kept indoors (housecats) and considered part of the family. Presently, in the US, for example, 1.2 billion animals are kept as pets, primarily for bonding purposes.[91] In addition, as of 1995 there were over 30 research institutions looking into the potential benefits of the human animal bond.[90]

Other bonding interests as of late include, feline-bonding, equine-bond, and parrot-bonding. To bond with a young parrot, for example, many people are under the mistaken impression that one must hand feed a baby parrot from babyhood for it to 'bond' to them. While it's true that a hand fed chick will bond to its care giver, it's also true that a well socialized, weaned chick will forge a new bond with a new owner, regardless of whether the owner hand feeds or not. Just as sexually mature bird forge new bonds with their chosen mates, birds have the ability to bond with different people throughout their lifetime.[92]

Human-insect bond

In entomology, researchers study the *human-insect bond* or 'bug bonding', which includes all types of symbiotic or adverse relationships between insects and humans. Examples of the symbiotic variety include butterfly farming or someone who cares for bees in order to harvest honey as an occupation. The West Nile Virus, which is carried by mosquitoes, is an example of an adverse variety of the human-insect bond.

In the recent 2004 book *Buzz - the Intimate Bond between Humans and Insects*, for example, entomologists Josie Glausiusz and Volker Steger explore the nature of the human-insect bond using electron microscope as a visual guide. In their book, they investigate the subtle and in many cases unnoticed neighborly bonding that goes on between humans and the very small creatures that, for example, pollinate our crops, dispose of our trash, help solve crimes, get stuck to our windshield, and live under the fridge.[93] A large number of insects, such as lice, cockroaches, clothes moths, bedbugs, carpet beetles, silverfish, houseflies, mosquitoes, ants, and fleas, i.e. any insect that can feed on human food, human skin, human blood, or human waste, etc., owe a large part of their existence to the fact that they have allied themselves with humans.

From another perspective, many people bond with or collect insects as pets and performers, such as a flea circus, an ant farm, or crickets for cricket fighting. Lastly, as an interesting example, many people bond well with the giant Madagascar hissing cockroach, which is a favorite collectable.

Social bonding

The *social bond* or 'social bonding' refers to the adhesive elements or results of the dynamic interaction of the individual and the group, often in respect to welfare, that tend to form cooperative and interdependent relationships with others of one's kind.[94] Social bonding, e.g. going to a movie, a baseball game, or a town festival, etc., is often characterized in terms of social links, which connect the group.

One of the first to write about the 'social bond' in depth as well as 'social links' was American philosopher and psychologist James Baldwin in his 1897 book *Social and Ethical Interpretations in Mental Development: A Study in Social Psychology*. In a section focused on personal intelligence, Baldwin delves into a discussion on desire, specifically in terms of the end result of the desire, such as an object, the possession of an object, the enjoyment of an object, self-realization, the attainment of a better self or life, etc.[95] In efforts to subsume these diverse statements into a general formula, he states that the 'reason for this variety is that the desire is a function of the thought which lies back of it.' The examination of the thought, according to Baldwin, 'is the necessary preliminary to the determination of the kind of desire and its end.' In this manner, to derive a philosophical theory of the end of

human action that satisfies all the conditions of the thought, one must 'find general distinctions in the content of thought at the different epochs of human development' and that this defines 'social life'.

Baldwin argues that in the 'sphere [of] the evolution of social life' a child as well as adults will imitate what they see, e.g. a newborn imitates movements, an adult strives towards his or her role model. He continues, the 'thought gives him the present possibility to act; and his present act gives him the new thought. So action and thought grow together as correlative aspects of intelligence.' To consider the social interpretation of this state of things in a person's life, Baldwin states that a person's interpretations are a function of personal growth, that depend on his or her social surroundings, the social factors involved in them, which is most clearly brought out in the sphere of social suggestion and how these social elements relate to a person's interpretation of *social value*. In other words, according to Baldwin, 'what is the content of the thought which stimulates the child to social actions and what are the actions which are reasonably performed with this end in view.'

The benefit of the *alter ego*, Latin for 'the other I', and is a second self, a second personality or persona within a person, 'depends upon the suggestions which he makes' and that these 'suggestion-influences he sees to be reciprocal.' A child, for instance, has a way of bringing his or her mother or father's actions 'into the series of events which contribute to his own ulterior thought.' The child's crying, in Baldwin's view, 'leads the mother to bring food; the cry is the suggestion upon which the mother can be counted to act.' Hence, very early the child learns to use crying as a *social tool* to 'obtain food or other favors from his mother, even if he is in no need' and that the child only knows that pleasurable memories hover before him in his mother's presence. In the child then comes the thought that certain actions of his mother's presence brings pleasure and that the action of his cry 'will be the appropriate suggestion to start the mother.' Hence, the child, as we all do, makes use of a means to and end.

Accordingly, according to Baldwin, 'the interesting thing from our present point of view is that the first link in the chain which the child uses is a *social link*.' Moreover, 'it really involves using his intelligence to direct and employ, for his own private ends, the social influence.' Here, as Baldwin fascinatingly states, 'we have possibly the first use of the *social bond* by the individual's intelligences; and in it there lies, by implication, all the conscious power and function of thought in the manipulation of society.' To summarize, 'this is the social function of thought everywhere when considered as the instrument of the thinker's use of society in contrast with society's use of the thinker and his thoughts.'[90] In modern terms, we understand that this is a quantum-thermodynamic process in which solar fluxed photons drive the social mechanism of the process, an energy that reciprocates onto each other in exchanges, which result in growth, mental, physical, and social.

Over the years, the use of the concept of the social bond, its theory, in its many variations, such as can be found in Robert Nisbet's 1970, 425-page, book *The Social Bond: and Introduction to the Study of Society,* are many and varied. In 1984, writer Colin Wilson, in his *A Criminal History of Mankind*, argued that the inability to form social bonds is the precursor to criminal activity. He states that 'insecure *social bonds* prevent a capacity for love and affection from being channeled into stable relationships, and the resentment lies dormant, like a volcano, waiting to be detonated into violence by stress.'[96]

In biochemical terms, some have begun to define social bonding in terms of changes in the expression of *neuropeptides*, which is a type of amino acid that influences neural activity or functioning, such as in relation to their expression in *dopamine*, 'the drive-chemical', producing reward centers or pleasure centers. In simple terms, operative functioning of these neural circuits is conducive to social behavior, whereas dysfunctions in these same systems can be associated with abhorrent social behavior, e.g. autism.[97]

In the last few decades, for instance, work on animals, such as voles and sheep, has begun to reveal the neural substrates and neurochemical systems that control monogamous bonds and parental bonds and some have used this data to formulate social bonding theories. Surprisingly, according to neurobiologist Keith Kendrick at the Babraham Institute Cambridge, these same systems may also become activated when humans form or dissolve social system and as such may act in the formation and dissolution of social bonds.[97] There is no point in being able to bond to someone unless, according to Kendrick, 'you can recognize them' and that sensor stimuli mediated by neurochemistry is what determines this recognition and subsequent social bonding.

In chemical terms, this process is called *molecular recognition*, which refers to the specific interaction between two or more molecules through noncovalent bonding such as including hydrogen bonding, metal coordination, hydrophobic forces, van der Waals forces, pi-pi interactions, and or electrostatic effects.[98] In human chemistry, human molecular recognition refers to either sexual recognition, the interaction of two or more human molecules through human chemical bonding, or interaction of mega-groups of humans via social interactions and bonding, also known as Müller dispersion forces.[99] In supermolecular chemistry, the host and guest involved in molecular recognition exhibit *molecular complementarity*.[100]

In neurological terms, brain neuropeptides such as oxytocin and vasopressin, which are known to be associated with formation of *social bonds*, according to Kendrick, are also involved in promoting social recognition memory. Evidence for this has been found primarily for odor recognition, and it seems to involve the potent facilitatory actions that these peptides have on the amount noradrenaline released within the brain. There is, however, some evidence in sheep that visual cues from faces can also provoke brain oxytocin release.[97]

In short, social bonding will only occur if their receptors are highly expressed in brain dopamine-producing regions associated with reward. In females that bond selectively with offspring after giving birth, or form monogamous pair bonds after sex, oxytocin receptors are highly expressed in a region of the brain called the *nucleus accumbens*, a region of the brain thought to play an important role in reward, pleasure, and addiction, where the peptide can facilitate brain dopamine release.[97]

In species that do not form these solely monogamous bonds, however, this relationship with dopamine reward centers is much weaker. The same is true of the vasopressin system, which promotes bonding responses in males, although the *ventral pallidum*, a region of the brain that controls motor activities with is associated with strong motivational or emotional constructs, is the critical dopamine-producing reward site involved. In this case, however, specific DNA microsatellite repeat sequences have been identified in the gene encoding the V1a receptor for vasopressin, which actuate to increase receptor distribution in the ventral pallidum.[97] Remarkably, artificially taking the 'social bonding' version of this gene from a monogamous prairie vole and expressing it in this brain region in an asocial promiscuous species, the meadow vole, will convert the latter to the ways of social monogamy. Humans also have a number of polymorphisms in the V1a receptor gene and there is a small but significant association between these and autism.

In the Internet age, the new phenomenon of online social bonding, also known as *e-bonding* or *i-bonding*, with people connected to on the net is a subtle, but very real variation of social electronic linking with distant others. In her 2002 book *Connecting: How We Form Social Bonds and Communities in the Internet Age*, author Mary Chayko investigates how physically separated, but mentally-linked, people manage to create a sense of virtual connectedness, a meeting of the minds, and feel undeniably, if unexpectedly, bonded.[101] Through dozens of personal accounts, the she considers the social fallout of connecting with absent others as well as with the benefits and hazards of internet communities, societies, relationships, and individual selves. The result is a comprehensive yet intimate look at social bonding as it is rarely recorded: an examination of the bonds and communities we form across great distances, and even across time, in the age of the Internet.

Societal bond

The *societal bond* refers to those cohesive elements and structural ties, as economic activity, unions, trade, sanctions, etc., which function to bind societies into collective units. Marriage, for instance, is one dynamic that functions to cement the societal bond.[102] In many societies marriage links not just nuclear families but larger social formations as well. Some endogamous societies are divided into exogamous groups, as clans or lineages. Here, men form alliances through exchange of women, and the social organization regulates these alliances through marriage rules.[102]

In 1993, British sociologist J. A. Mangan positioned a theory on the relationship between sport, empire, society and the cultural bond.[103] The *cultural bond*, in this sense, are those activities that facilitate the formation and health of those adhesions which define the structure of culture. Of significance, sport, according to Mangan, is much more than merely an agreeable recreation; it is a status of a moral discipline, a symbol of solidarity, of imperial superiority, even a salve for conscience, and hence a central thread in the fabric of the cultural bond. His view is that sport is an important instrument of cultural association, subsequent cultural change, promoting at various times and in various places unity, national identity, social reform, recreational development and post-imperial goodwill.[104]

Aside from these basic bonding or bond forming examples, there are bond types on the opposite end of the spectrum, which fall under the category of debonding or detachment, i.e. the dissolution of a bond. In addition, there are other non-typical bonding terminologies, such as placeholders, adoption bonding, or capture bonding. Below we will touch on a few of these.

Placeholders

In 2003, American psychologist Robert Berend coined the expression *placeholder relationship*, as a term that identifies a relationship where one or both parties knows the other is not satisfying their 'wish-list'.[105] This can be described as a sort of bond or attachment similar to the oft-heard suggestion ‘when swinging through the jungle, don’t let go of your old vine until you have a new one to grab onto.’ Hence, in short, a placeholder relationship is like an old vine that one is afraid to let go of because they don’t want to fall to the jungle floor.

In a placeholder relationship, according to Berend, a situations accrues in which due to certain unfulfilled needs or wants, e.g. loneliness, sex drive, extroversion, frustration with lack of dating, no better option available, etc., an ongoing relationship exists for the time being, but one in which at least one person knows this will not be a permanent relationship, but are getting some type of value from it. This could be sex, status, money or other tangible rewards, or just someone to relieve boredom or loneliness.

Debonding

The polar opposite to the evolutionary process of human bonding is the evolutionary process of human debonding. In human reaction terms, *debonding* is the process by which relationships come apart.[106] The related term ‘breakup’, refers to the point in time in which their occurred a complete split or rupture in the bond. In retrospect, a pair that splits is often dismissed as having been a failed relationship.[107] This latter

term, however, incorrectly implies that all decomposition or dissolution reactions are in some way 'failures'. In molecular terms, a decomposition reaction is of the form:

$$AB \rightarrow A + B \qquad [14.1]$$

In a laboratory, if it were the desire of the chemist to decompose species *AB*, then a reaction of the form of [14.1] would be considered 'successful' as long as it went to completion. A failed reaction, conversely, would be one that did not go at all. Thus, success or failure is a point of view.

Again, right and wrong, in the universe, is a point of view. If two people bond into a working relationship for a number of years, such that the reaction is good as it yields a significant amount of productive work, but then goes bad, the correct view is to divide the reaction into phases, i.e. the attachment phase, which includes the initial portion of the reaction, the thermalization phase, which includes the mid-period in the reaction where things are going good, and the detachment phase, which begins the moment the relationship stops working, a point that can only be discerned in retrospect, and finalizes when the pair no longer has any association.

In other situations, there are relationships or reactions that *equilibrate* or come to be in equilibrium between makeups and breakups. The essence of this type of reaction was captured by the 1973 song by the *The Stylistics*, where the chorus is:

"Break up to make up, that's all we do
First you love me then you hate me, that's a game for fools."

These indecisive pairings or titter-totter relationships, where a couple repetitively breaks up and then reforms are technically called ambivalent relationships, which are characterized by chemical *equilibrium bonds*. In molecular terms, these equilibrium relationships are of the form:

$$AB \leftrightarrow A + B \qquad [14.2]$$

This two-way reaction arrow was first used by Dutch physical chemist Jacobus van't Hoff in his 1884 *Études de Dynamique chimique* (*Studies in Chemical Dynamics*), in which, to elaborate on the dynamic nature of chemical reactions, he replaced the previously used equals sign '=' in chemical equilibrium reactions.

In [14.2], the state of the relationship is such that it both absorbs and releases working energy from the life of the pair in equal amounts; confusion results. These types of reactions are difficult to deal with; people in such relationships will tend to break up and then get back together again many times over. Typically, however, by

the fifth or so breakup such couples seem to catch on to the underlying pattern in their teeter relationship and in finality agree to call it quits.[108]

Several decisive factors will often signify the end portions of debond stage. One key turning point is when a couple begins to mentally rewrite their relationship history. In interviews of couples on the brink of divorce, psychologist John Gottman notes that couples who are deeply entrenched in a negative view of their spouse and their marriage often rewrite their past. When unstable couples are asked about their early courtship, their wedding, or their first year together, they often reconstruct their early bond reaction days so that they come into a new light, but with a negative connotation. In happy marriages, conversely, couples tend to look back on their early days fondly.[109]

When the end draws near in a relationship, couples will find themselves on red alert. In this state, they will always expect to do combat, such that the marriage becomes a torment. The result is that first one then both will withdraw from the relationship. At this point in the debonding stage, however, one or both of them will have already disengaged emotionally from the marriage. Some people leave a marriage literally, by divorcing; others do it by living *parallel lives*, i.e. living as co-habiting strangers. However one leaves according to Gottman's research, there are four final stages that signal the death knell of a bond:

1. One or both see their marital problems as severe.
2. Talking things over seems useless; one or both begin to solve problems on their own.
3. One or both start leading parallel lives.
4. Loneliness sets in.

When a couple gets to stage four, one or both partners may have an affair. In terms of the health of the relationship, according to Gottman:[109]

> "An affair is usually a *symptom* of a dying marriage."

Statistically, on average, 22% of adults worldwide have claimed to have had an extra marital affair.[110] The promiscuous Turks, of all nationalities, lead the race with 58% having claimed to have had an extra marital affair, while Israel claims the lowest rate with 7%.[110]

Detachment

In attachment theory psychology, *detachment* is a product of the activity of a number of behavioral systems that have remoteness and distance to a person, e.g. a mother, a mate, a friend, etc., as a predictable outcome. In short, detachment is the opposite of attachment; or the *detachment reaction* is the reverse of the attachment reaction.

In the 1960s, John Bowlby collaborated with British psychiatric social worker James Robertson, who focused his research on separations of mother and child due to hospital admission. Between the two of them, they derived a classic theory about the phases of protest, despair and denial, through which small children pass when isolated from their mothers for a length of time. Bowlby called this last stage detachment.[23]

Between the two of them, through studies of maternal-child separations at long-stay hospitals that 'the young child's hunger for his mother's love and presence is as great as his hunger for food', and that in consequence her absence inevitably generates 'a powerful sense of loss and anger'. Upon observations of a child's behavior once returning home, they noted that either the child would 'intensely cling to the mother which can continue for weeks, months, or years' or, on the other had, 'a rejection of the mother as a love object, which may be temporary or permanent.' To latter state, namely *permanent rejection*, they assigned the name *detachment*.[111] In this situation, Robertson and Bowlby reasoned that the child's feelings for his mother had undergone *repression*, i.e. the previous idea, wish, or desire to do or act, once conscious in the mind and at the fore, had disappeared and now lies dormant in the mind if at ever to return.

Some recently have argued that there exists a relationship between attachment, detachment, and nonattachment in human's lifelong patterns of emotional, physical and mental health and growth. The basic premise argued is that people relate to their environment with attachment (intimacy) and detachment (autonomy) from their earliest (prenatal and perinatal) experiences. Ultimately people strive for synthesis of the two, i.e., balancing attachment, i.e. freedom from fear of abandonment, with detachment, i.e. freedom from fear of engulfment, resulting in liberation from the subjugation to either or the freedom to explore the external and internal worlds.[112] Similarly, according to psychologist Jeremy Holmes, to distinguish the three terms, '*attachment* arises out of a secure base, provides the starting point for the capacity for healthy protest and therefore *detachment* is the basis of autonomy; from *non-attachment* comes the capacity to reflect on oneself and so to dis-identify with painful or traumatic experience.[113]

In relationship terms, a breakup, from a detachment-theory point of view, is the permanent rejection of a mate. The *detacher*, i.e. the person who sub-consciously initiates the detachment process, no longer has the idea, wish, or desires to do or act with the detached partner. Once there is no longer further exchange, in any respect, we then say that the detachment process has finalized, although the residual feelings of the previous attachment, analogous to the phantom limb phenomena, may reside in the mind for an extended period of time if at ever to dissipate.[114]

Uncoupling

In relationship dynamics, *uncoupling* is the process in which intimate relationships come undone. The definition stems from the early 1970s work of an American graduate student in sociology, at Ohio State University and later as a post-doctoral fellow at Yale University, named Diane Vaughan who began to study the orderly dissolution of the typical marriage. She was inspired in this direction after reading a 1964 article titled 'The Social Construction of Marriage' by Peter Berger and Hansfried Kelner, which described marriage as a process in which two individuals renegotiate who they are with respect to each other and the world around them.[115]

Building on this article, and after interviewing hundreds of people in the years to follow, by 1976 Vaughan had developed 'uncoupling theory', according to which, during the dynamics of relationship breakup, there exists a *turning point*, only noted in hindsight, followed by a transition period in which one partner unconsciously knows the relationship is going to end, but holds on to it for an extended period, sometimes for a number of years.[106] In simple terms, according to Vaughan, 'uncoupling begins with a unconscious secret, one of the partners starts to feel uncomfortable in the relationship, then the world of the two of them have together no longer fits.' These original and correct views culminated in the publication of the exceptional 1986 book *Uncoupling – Turning Points in Intimate Relationships.*

In most relationships that end, the second half or phase of the reaction will often correlate to a slow decomposition. Someone married for twenty years, in retrospect, will look back and notice that the marriage seemed to have been coming slowly apart for the last ten. Certainly, such a marriage reaction will have had its good times, but retrospectively on can pick out turning points, i.e. moments when the relationship changed, times when the distance between the reactants increased.[116] These turning points, according to Vaughan, do not directly hinge around arguments or the typical emotional catastrophes that best any relationship, but instead appear to be related to changes in each person's social world.

Using her own life as an example, Vaughan states, in analysis of her multi-decade marriage that ended in divorce, that she originally started college because she realized that she was never going to have the steady companionship of her partner and that she needed something of her own to do. This step, innocently taken, she says, 'changed her' and their relationship. As their marriage aged, she says, 'we *reacted* to out difficulties by altering our relation to the world around us. Those changes, in turn, affected the relationship, changed us as individuals and our relationship to each other.' What's more, she says, 'as I thought about our relationship in terms of our maneuverings in the social world, it seemed as if our marriage had eroded slowly and steadily over time in a regular, ordered way.' Interestingly, she continues, even though they personally experienced the ending of the relationship as chaotic and disruptive, 'its demise took on a kind of social

rhythm' and 'that an experience could be orderly and disorderly at the same time was counterintuitive.'[116]

In chemical dynamic terms, order and disorder in a debonding chemical reaction are quantitatively measured via changes in entropy [3.11].[117] Moreover, the steady erosion of a marriage reaction in a sequential, steady, ordered way, over time, is a step-by-step process defined by a *reaction mechanism*, which in chemical terms is the is the step by step sequence of elementary reactions by which overall chemical change occurs.[118] A read-though of any good organic chemistry textbook, such as Seyhan Ege's 2003, 5th edition, *Organic Chemistry – Structure and Reactivity,* will provide the inquisitive reader with a general overview of reaction mechanisms.

In her research, Vaughan noticed that when two people marry, they redefine themselves as a couple, in their own eyes and in the eyes of others, who respond to the coupled identity they are creating. They are invited out as the twosome, mail comes addressed to both, the IRS taxes them jointly, etc. Likewise, single friends may hesitate to call, while the two people are readily incorporated into the social world of those who also are coupled. In Vaughan's view, relationship deterioration is the reversal of this process, i.e. the two people slowly and over time begin to redefine themselves as separate people. Rather than an abrupt ending, debonding seems to have a gradual transition. That is, long before two people physically separate, they separate socially, i.e. develop separate friends, experiences, and futures. The two separating people will react to their changing relationship in ways that alter the previous definitions that they held for themselves and that others held for them.

Adoption bonding

A child adoption services, *adoption bonding* refers to the mutual affectionate connection that is cemented between a child and a parent, whether the child is a biological child or an adopted child. The process of establishing this connection includes a growing feeling of entitlement to family life, love, responsibility and a variety of other emotions normally experienced by a parent and child.[119] Technically, according to researchers in this field, *bonding* here refers to the process and *attachment* is the result.

In adoption, most extend the terms bonding and attachment to apply to any two individuals who fit certain parameters. Psychologist Tiffany Field, for example, defines attachment as 'a relationship between two beings which integrates their physiological and behavioral systems.'[119] Yet, some adoption experts believe the terms 'bonding' and 'attachment' are far too loosely used. Jean Nelson-Erichsen, co-director of adoption at Los Ninos International Adoption Center in The Woodlands, Texas, for instance, states 'this overused word *bonding* sometimes drives me wild. You don't usually just fall in love with people and become all warm and cuddly in

days! And a lot of people whose babies are born to them don't immediately love their babies. The way you *bond* with children is to hold them and play with them and read to them. All the holding and caring things are important.'[120]

To elaborate on this difficultly many sociologists and psychologists have in distinguishing between the terms bonding and attachment, we point out that from a human molecular point of view, the process of human life follows attachment, reaction, and bonding patterns similar to those involved in protein interaction. The classic model, showing the four distinct steps in the reaction between two proteins *R* and *L*, is shown below:[121]

$$R + L \quad \leftrightarrow \quad R \cdots L \quad \leftrightarrow \quad R - L \quad \leftrightarrow \quad RL \qquad [5.3]$$

"close proximity" "encounter complex" "transition state" "bound state"

In human terms, the reaction is the same; thus, for example, *R* and *L* could be two people, namely and man and a women, *Mx* and *Fy*.

To elaborate further, in the bound or attached reaction phase, the bound state protein structure *RL*, or bound human couple *MxFy*, will also go through many relationship isomerization reactions during the 'state' or evolution of its bound interactions. To represent these changes, we can use various isomerization symbols to signify the state or type of bond transformation during each step of the relationship or attachment change:

$$R{\equiv}L \leftrightarrow R{=}L \leftrightarrow R{\overline{\overline{\ }}}L \leftrightarrow R{\underline{\underline{\ }}}L \leftrightarrow R{\overline{\underline{\ }}}L \leftrightarrow R{-}L \leftrightarrow R{\|}L \qquad [14.3]$$

Here, the symbols, '≡' (twelve thermodynamic ties), '=' (eight thermodynamic ties), '$\overline{\overline{\ }}$' (a relationship turned upside down), '$\underline{\underline{\ }}$' (a relationship running right-side up), '$\overline{\underline{\ }}$' (a matrixed relationship), '–' (four thermodynamic ties), or '$\|$' (a relationship focused on R), etc., represent different states of the ongoing relationship.

Moreover, at the dissolution stage of the process, in which the two enhanced proteins (or two enhanced humans) detach, a reverse process to that of [5.3] will actuate in the form of a de-bonding or detachment reaction:

$$RL \quad \leftrightarrow \quad R - L \quad \leftrightarrow \quad R \cdots L \quad \leftrightarrow \quad R + L \qquad [14.4]$$

"end-bound state" "de-transition state" "de-encounter complex" "far proximity"

Then, of course, the far proximity stage will evolve naturally into the *no proximity stage* in which there is no interaction and there will never be any further interaction. In sum, the terms bonding and attachment are simply over-arching labels for what is a more involve, multi-year, reaction process, with may stages or states.

In adoption practice, a major point of interest and focus is the 'timing' of the adoption bonding. Psychiatrist Michael Rutter provides some information on this point. Rutter found that the idea that there are 'sensitive periods', i.e. *bond windows* in which children will generally attach successfully to the system of the adoptive parents. His studies have shown that children who were adopted before the age of four bonded well with their parents while children who were over age four experienced many of the same problems as children who remained in an institution.[122] Rutter also supported the idea that even children adopted after the age of four years could bond with adoptive parents, but only through different mechanisms.

The bonding process typically begins with a photo of the child through which the parents begin to develop pre-conceptual ties. The time when they first view the baby or older child is very important and unforgettable to most adoptive parents, as if it were *imprinted* in their brains along with other important scenes of their lives.[119] In fact, many adoptive parents have reported that they bonded to the child based on his or her picture alone, especially in the case of an international adoption, when the decision to adopt was based solely on the photo, a sketchy description or a videotape or Internet web site introduction.[119] Moreover, when such an adoption has fallen through for some reason, adoptive parents actually experience a grieving process, even though they have never met the child.

Bonding failures

In 1970s, American social worker Frank Bolton spent a number of years studying dysfunctional families from the viewpoint of Harlow's wire-mesh rhesus monkey experiments and Bowlby's attachment theory to develop a unique view on the correlation between early life abnormal bonding interactions to that of later family violence. In his 1983 book *When Bonding Fails – Clinical Assessment of High-Risk Families,* Bolton discusses the various abnormal repercussions related to family bonding failures, e.g. situations such as wife-batter, child neglect and abuse, child sexual abuse, and marital rape. Each of these situations, according to Bolton, tend to be a direct result of early parent-infant bonding failure.

In short, through his interviews and research Bolton finds that in families that are seriously dysfunctional and chaotic, those parents who abuse their children, tend to have experienced a high 'degree of impairment of early bonding and attachment between parent and infant.' Moreover, Bolton discerns that these abnormal family situations are a type of evolutionary survival mechanism in which people react in ways to cope with limited physical and emotional resources. In contrast to the views of Konrad Lorenz, who argued that humans were the only species that regularly killed their own, Bolton points out that lions, hippos, bears, wolves, hyenas, and at least fifteen other species of primates other than man do so as well.

In family situations in which resources become scarce, include those involving young parents, multiple pregnancies in quick succession, as well as basic economic hardship, bonding failures will tend to actuate. Throughout history during times of economic stress, cannibalism of infants and young children are known to have occurred under extreme famine conditions. Bolton references Colin Turnbull's 1972 book *The Mountain People*, described by Margaret Mead as 'a beautify and terrifying book, emphasizing again and again how fragile the structure of a society is,' as an example of basic human bonding failure in a culture near its end.

According to Bolton, there is no greater contradiction than that between the perception of the family as a warm, safe, and happy, place and the record of known family violence. He notes that family advocates suggest that it is inconceivable for parents to respond to their child as though it were merely and 'inanimate thing', but they do. A complete failure to respond and bond to a child's needs is unthinkable, yet it occurs regularly. Violence, according to Bolton, 'is a part of some families, a part that may never change.' In sum, bonding failures is the study of why some families engage in violence when confronted with certain stresses while others do not.

Shattered bonds

In child welfare science, *shattered bonds* or 'shatter bonding' is the process in which child welfare agencies take children from troubled low-income families puts them into middle-class, but not necessarily stable, households.[123] The concept, issues, and theories of shattered bonds was developed by Northwestern University law professor Dorothy Roberts, as presented in her 2001 book *Shattered Bonds: the Color of Child Welfare*, in which she addresses the often-precarious situation where child welfare workers must decide between leaving a low-income child with its natural mother, who may have substance-abuse issues or financial difficulties, among other factors, or to detach the child from the usually well-intentioned, but inopportune mother and attempt to bond it to foster parents.[124]

This pits the logic of Bowlby's 1969 attachment theory views, which argues that the best course of early child development is to have a natural child-parent bond, regardless of situational environment, against other aspects of bonding theory, namely Anna Freud's 1973 child psychology views, which argue that child raised on an unstable maternal attachment platform will result in the formation of unstable adults and that most children can be conditioned to form bonds of attachment with other adults who will fill the role of parent.[125] To further compound the bonding issue are studies indicating than near to fifty percent of children in foster care end up in jail. Moreover, in terms of racial factors, in America particularly, statistics indicate that black children make up half the foster-care population despite the fact that they constitute less than one-fifth of the nation's children and that public policy

may be biased towards separating children from troubled low-income black families while making efforts to keep similarly troubled white families together.[126]

Reactive attachment disorder

In psychology, *reactive attachment disorder*, i.e. the inability to attach, is a psycho-physiologic condition associated with markedly disturbed and developmentally inappropriate social relatedness in most contexts that begins before five years of age and is associated with grossly pathological care.[127] In mental retardation, attachments to caregivers are consistent with the level of development. In pervasive developmental disorders, attachments to caregivers either fail to develop or are highly deviant, but this usually occurs in a context of reasonably supportive care. Due to maltreatment by caregivers, however, reactive attachment sufferers tend to have difficulty forming healthy relationships with their caregivers, peers and families. Reactive attachment disorder can reportedly be diagnosed as early as the first month of life.[128] One recent study by the National Adoption Center found that 52% of adoptable children, meaning those children in U.S. foster care freed for adoption, had symptoms of RAD.[128] Other estimates range from 10 to 80%.[129]

Capture bond

In evolutionary psychology and abnormal psychology, *capture bonding* is a term used to define the bonding that in some instances develops between the captor and captive, or terrorist and hostage, and is sometimes referred to as Stockholm syndrome.[130] The term stems from the 1973 case of a Swedish woman who became so attached to one of the bank robbers who held her hostage that she broke her engagement to her former lover and remained bonded, or in bondage, to her former captor while he served time in prison.[131] In this traumatic situation, the victims became emotionally attached to their victimizers, and even defended their captors after they were freed from their six-day ordeal. This behavior came to be called 'Stockholm syndrome' a term coined by the criminologist and psychiatrist Nils Bejerot, who assisted the police during the robbery, and referred to the syndrome in a news broadcast. In the 1980s and 90s, the psychological concepts behind this abnormal behavior began to find analogies in the fields of abnormal psychology and evolutionary psychology, wherein the term *capture bond* developed.

Capture-bonding theories are used to explain various relationships, such as kidnapping or tribe takeover, in which a person seems to be 'caught' unhealthily or abnormally in a bond, even when given many chances to escape. The general explanation is that a sort of reverse-psychological mechanism or perspective develops in which, after a traumatic event, the captive person willing desires or stays in the bond. In abnormal psychology, *battered women syndrome*, where a woman

stays bonded to a man who beats her, is an example of an activated capture-bond.[132] In evolutionary psychology, capture-bonding is understood as an evolved response to inter-tribe 'capture' and takeover, which has been a prominent feature of human existence during the last few million years, such as infanticide, which occurs frequently in the animal kingdom.

The origin of the concept of capture-bonding stems from a 1972 conversation between American psychologist John Money and American cultural anthropologist Margaret Mead in an elevator in a hotel in Stockholm. They had just finished working on a subcommittee report for a conference they were attending, one of a series on stress. They decided at that point that one of them would have to write a book on the subject.[133]

In the following year, the famous six-day Stockholm bank robbery occurred, i.e. the Norrmalmstorg robbery of *Kreditbanken* at Norrmalmstorg, Stockholm, Sweden, in which the bank robbers held bank employees hostage from August 23 to Augus 28 in 1973.[131] In this case, the victims became emotionally attached to their victimizers and even defended their captors after they were freed from their six-day ordeal. Influenced by this event, Money eventually wrote two books about abnormal bonds, i.e. the 1980 *Love and Love Sickness – the Science of Pair-Bonding* and the 1986 *Lovemaps,* in part based on this theory of psychological stress capture resulting in the formation of a bond, among other topics.

Others to have arrived at the concept of capture bonding include evolutionary psychology John Tooby who in about 1980 began discussing the concept of capture-bonding with his students. In 2001, American electrical engineer Keith Henson arrived at the same conclusion in its evolutionary origin and widespread effects on humans and human societies.[134] In 1986, Money used the concept to explain abnormal development of lovemaps.[135] In his 1986 book *Lovemaps*, for example, Money states: 'a kidnapped sexual partner who foregoes opportunity for escape remains in a strong *bond of attachment* to the kidnapper. Until the *bond* is broken by outside intervention, it persists with all the defiant resistance of the phylism of infatuation and the limerent love affair.' In the 2006 book *From Princess to Prisoner,* by Linda McJunckins, the theory of capture bonding is used to explain the behavior of a daughter who suddenly relinquished her freedoms as a college student to an arduous life as a slave among strangers.

The application of capture bonds to the concept of lovemaps, i.e. neurological bonding predispositions accumulated during youth though association, is a difficult psychology. According to Money, 'for the average person it is an enigma that a wife would stay married for twenty-five years to a husband whose paraphilic sadism was always injuriously abusive; or that an abducted ten year old boy would pass up many opportunities for escape for this pedophilic abductor and stay with him after witnessing the lust murder of another boy his own age.' Money states that this is referred to as Stockholm syndrome, which he defines as 'the *bond* that in some

instances develops between captor and captive, or terrorist and hostage' and that 'this syndrome, more broadly defined, may be regarded as applying across the board to all of the paraphilias in which one partner exercises paraphilic power and the other becomes *collusionally-bonded* to the paraphile as an accomplice.'

Money uses the 1976 Baltimore pedophilic lust murder Arthur Goode, who at the age of twenty abducted a newsboy from a professional family and co-opted him as his boy lover.[136] The child had opportunities to escape, even after he was witness to the lust murder of another boy his own age. It was only after the police were notified, that he could disengage himself from the mysterious bond with his abductor. Hence, according to Money, 'a kidnapped sexual partner who foregoes opportunity for escape remains in a strong *bond of attachment* to the kidnapper. Until the bond is broken by outside intervention, it persists with all the defiant resistance of the phylism of infatuation and the limerent love affair.'

Essentially, the lovemap theory entails that during early childhood development people develop neurological 'maps' as they associate to their surroundings. Resultantly, as adults, those who have experienced abnormal development in youth will have the tendency to 'bond' stronger in similar abnormal situations. Hence, if one was made to feel predisposed towards the 'captive' lifestyle in youth by their 'captor' surrogates, friends, or parents then later in life he or she will have a greater tendency to sink into the *captive-bond*.

In 2001, American electrical engineer Keith Henson, in his article 'Sex, Drugs, and Cults', presented an evolutionary psychology explanation as to why such a trait as capture-bonding would have evolved in relations to the reproductive success of evolving people during the last 3.5 million years in which social primates lived in bands or tribes.[134] One commonality that stands out from records of the historical North American tribes, the South American tribes such as the Yanomamo, and some African tribes is that being captured was a relatively common event.

Going back a few generations, almost everyone in such tribes has at least one ancestor, typically a woman, who was violently captured from another tribe. Hence, the hypothesis has been put forward that natural selection has left us with psychological response to the capture process as seen with Stockholm syndrome and as in the Patty Hearst kidnapping. Subsequently, capture-bonding, or social reorientation when captured from one warring tribe to another, developed as an essential survival tool. Those who reoriented often survived to reproduce.

Thus, the evolutionary psychology explanation stresses the fact that all humans have ancestors who gave up and joined tribes that captured them. This selection process, as posited, accounts for the extreme forms of capture-bonding exemplified by Patty Hearst and the Stockholm syndrome. If humans have this trait, it accounts for the 'why' behind everything from basic military training and sex-bondage to fraternity hazing. That is, people may have a wired-in knowledge of how to induce bonding in captives. Captive-bonding thus accounts for battered wife syndrome,

where beatings and abuse are observed to strengthen the bond between the victim and the abuser, at least up to a point.

In animal psychology, the theory of capture bonding is used to explain various situations of infanticide, such as in lion or gorilla social systems, where a new alpha male takes over the troop and in doing so kills off all of the offspring. The females then, invariably bond to the new male and reproduce a new litter with him. Evolutionary psychologist Matt Ridley, in his 2003 book *The Agile Gene - How Nature Turns On Nurture*, explains that infanticide is common among gorillas, as it is among primates. A bachelor male, according to Ridley, will infiltrate a harem, grab a baby, and kill it. This has two affects on the baby's mother, apart from causing her great, though transient, distress. First, according to Ridley, 'by halting her lactation it brings her back into estrus; second, it persuades her that she needs a new harem master who is better at protecting her babies. And who better to choose than the raider? So she leaves her mate and marries the baby's killer.'[137] This is a form of pair-bonding resulting from a tribe or troop takeover in which the females are, so to say, 'captured' and converted into new reproducing brides.

Trauma bond

In abnormal psychology, trauma bonds or 'betrayal bonds' are defined as exploitive relationships.[138] In trauma bonds, there exist psychological chains that link a victim to someone who is dangerous to them. Divorce, employee relations, litigation of any type, incest and child abuse, family and marital systems, domestic violence, hostage negotiations, kidnapping, professional exploitation and religious abuse are all areas of trauma bonding. All these relationships share one thing: they are situations of incredible intensity or importance where there is an exploitation of trust or power.[139]

The conception of the betrayal bond was originated in 1997 by American sexual relationship addiction and recovery counselor Patrick Carnes who in the late 1980s began to theorize about bond interactions related to the detrimental effects of sexual addiction that, according to Carnes, are effects contrary to love.[140] A women who is forced to endure sexual abuse or perform acts of sex in order to keep their jobs and thus stay occupationally attached is an example of a trauma bond. Likewise, living in a toxic marriage or working in a toxic corporation, with daily acts of degradation, manipulation, secrecy and shame are further examples of trauma bonding in which, according to Carnes, a person becomes 'deadened over time'.

To give an analogy of what the trauma bond is like, such as in a bad marriage in which partner's are continuously tense and braced for the next outburst for years on end, Carnes states that the bond is 'like walking into a room with a bad smell.' The longer you stay in the room, according to Carnes, 'the more the smell will seem to dissipate', because the 'olfactory system adjusts to the offensive odor.' Moreover, 'it's only by leaving the room (stepping out of the bond) that you will recover your

sensitivity to the odor.' Hence, only after being away from the traumatic bond will a person's sensitivity return.

Carnes' clinical research has discerned patterns such as methods underlying the strength of trauma bonds, betrayal and trauma bonds, and how to recovery from trauma bonds. After a traumatic experience, according to Carnes, 'the human system of self-preservation goes on permanent alert, as if the danger might return at any moment' and that high-energy trauma bonds result.[141]

Continuity bonds

In cessation thermodynamics, a *continuity bond* or 'continuing bond' is a link to a deceased person active in the ongoing bonds of the living person. The phrase continuing bonds was first used in 1996 to refer to an aspect of bereavement process in the book *Continuing Bonds: Another View of Grief,* by Phyllis Silverman, Steven Nickman, and Dennis Klass, which challenged the popular model of grief requiring the bereaved to 'let go' of or detach from the deceased.[142]

The dominant 20th century model, they found, as stemming particularly from Sigmund Freud's 1917 paper *Mourning and Melancholia,* holds that the function of grief and mourning is to cut bonds with the deceased, thereby freeing the survivor to reinvest in new relationships in the present. Pathological grief has been defined in terms of holding on to the deceased. Close examination reveals that this model is based more on the cultural values of modernity than on any substantial data of what people actually do.[143]

From their data, they show that the bereaved maintain a link with the deceased that leads to the construction of a new relationship with him or her. This relationship continues and changes over time, typically providing the bereaved with comfort and solace. In some cases, a bond to a deceased person may be more powerful than all other living bonds combined. Many times, owing to cultural protocols, mourners struggle with their need to find a place for the deceased in their lives and are often embarrassed to talk about it, afraid of being seen as having something wrong with them.[142]

Presenting data from several populations and twenty-two authors among the most respected in their fields, they demonstrate that the healthy resolution of grief enables one to maintain a *continuing bond* with the deceased. Despite cultural disapproval and lack of validation by professionals, survivors find places for the dead in their on-going lives and even in their communities. Such bonds are not denial, but rather the deceased can provide resources for enriched functioning in the present.[143]

The development of a cessation bond is conscious, dynamic, and changing. Mourners' faith systems can affect the way in which they incorporate the departed into their lives. Some people believe that the deceased live in another dimension.

Many believe the deceased are there to intervene and support them. Others do not depend on a faith system but rather build the connection out of the fabric of daily life and the sense of the deceased they carry within them.[142]

The full scientific account of continuing bonds in relation to what happens to a person when they die, with respect the laws of thermodynamics, particularly the first law of thermodynamics, i.e. that of energy-matter conservation, was fully-detailed in a 2005, 100-page, book called *cessation thermodynamics*, as discussed in overview in chapter sixteen.[144]

15 – Advanced Topics:

"To be master of any branch of knowledge, you must master those which lie next to it; and thus, to know anything—you must know all."

Oliver Wendell Holmes, *American Physician*

The subject of human chemistry is vast and far-reaching. Goethe founded this new science in 1809, Fairburn wrote the first book on human chemistry in 1914, and here we have expounded on these footsteps by laying a rigorous foundation in a modern day chemical language and theory. There are several points to carry away from this presentation. First, each human being is a twenty-six element biomolecule, no different then any other molecule in the universe. Second, each human molecule forms chemical bonds with other human molecules, which configure in the shape of bonds, bands, nodes, hubs, links, chains, rings, dyads, connectors, ties, webs, caves, clusters, groups, associations, collectives, corporations, cultures, states, nations, etc. Third, the process in which human bonds form, break, and reconfigure is a chemical reaction, no different then any other chemical reaction in the universe. Fourth, the heat, work, energy, and frictional movements associated with these reactive chemical transformations are the subject of human thermodynamics. Many important subjects have been left untouched; here we will address a few of these.

Crystallization

In neurochemistry, *crystallization* is a concept, developed in 1822 by the French writer Stendhal, which describes the process or mental metamorphosis in which unattractive characteristics of a new love are transformed into perceptual diamonds of shimmering beauty.[1] In short, according to Stendhal:[2]

> I call crystallization that action of the mind that discovers fresh perfections in its beloved at every turn of events.

In the summer of 1818, Stendhal took a recreational trip to the salt mines of Hallein near Salzburg with his friend and associate Madame Gherardi. Here they discovered the phenomenon of salt 'crystallization' and used it as a metaphor for human relationships.[3]

In the salt mines, nearing the end of the winter season, the miners will throw a leafless wintry bough into one of the abandoned workings. Two or three months later, through the effects of the waters saturated with salt which soak the bough and then let it dry as they recede, the miners find it covered with a shining deposit of crystals. The tiniest twigs no bigger than a tom-tit's claw are encrusted with an infinity of little crystals scintillating and dazzling. The original little bough is no longer recognizable; it has become a child's plaything very pretty to see. When the sun is shining and the air is perfectly dry the miners of Hallein seize the opportunity of offering these diamond-studded boughs to travelers preparing to go down to the mine.[4]

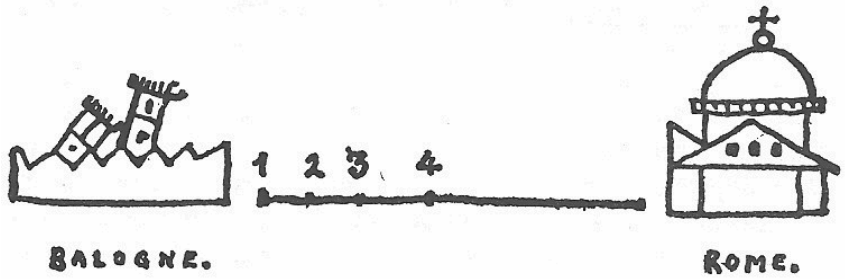
Along one particular trip into the 500-ft deep Salzburg mines, Stendhal and Madame Gherardi were introduced to an intelligent Bavarian officer who thereafter joined their company. Soon enough, the officer began to become quite taken by Madame Gherardi. The officer, according to Stendhal, could be seen to be visually 'falling in love' with her. What stuck Stendhal the most, as an undertone of madness which grew moment by moment in the discourse of the officer, was how the officer saw perfections in this woman which were more or less invisible to Stendhal's eyes. He began to praise Madame Gherardi's hand, for instance, which had been curiously marked by smallpox in her childhood and had remained very pocked and rather brown.[4]

Stendhal reasoned 'how shall I explain what I see'? He wondered 'where shall I find a comparison to illustrate my thought.' Just at that moment, Madame Gherardi was toying with a pretty branch covered with sparkling diamonds which the miners had given her. The sun was shining (it was the third of August) and the little salt prisms glittered like the finest diamonds in a brightly-lit ballroom. From this observation, Stendhal formulated his concept of mental 'crystallization' and thus set forth to explain it to Madame Gherardi, who was curiously unaware of officer's enhanced infatuation for her.

He told her, 'the effect produced on this young man by the nobility of your Italian features and those eyes of which he has never seen the like is precisely similar to the effect of crystallization upon that little branch of hornbeam you hold in your hand and which you think so pretty. Stripped of its leaves by the winter it was certainly anything but dazzling until the crystallization of the salt covered its black twigs with such a multitude of shining diamonds that only here and there can one still see the twigs as they really are.' That is, 'this branch is a faithful representation of la Ghita (Madame Gherardi) as viewed by the imagination of this young officer.'

Thus, according to Stendhal, the moment one begins to take interest in a person one no longer sees him or her as they really are, but as it suits one to see them. According to this metaphor, one sees flattering illusions created by a nascent interest; illusions analogous to pretty diamonds hiding a leafless branch of hornbeam, perceived only by the eyes of the one falling in love.

Stendhal describes or compares the 'birth of love' in a new relationship as being a process similar or analogous to a trip to Rome. In the analogy, the city of Bologna represents *indifference* and Rome represents *perfect love*:



Stendhal's 1822 depiction of 'crystallization' in the process of falling in love.

When we are in Bologna, we are entirely indifferent; we are not concerned to admire in any particular way the person with whom we shall perhaps one day be madly in love with; even less is our imagination inclined to overrate their worth. In a word, in Bologna 'crystallization' has not yet begun. When the journey begins, love departs. One leaves Bologna, climbs the Apennines, and takes the road to Rome. The departure, according to Stendhal, has nothing to do with one's will; it is an instinctive moment. This transformative process actuates in terms of four steps along a journey:

1. **Admiration** – one marvels at the qualities of the loved one.
2. **Acknowledgement** – one notices the return affection of the charming person.
3. **Hope** – one envisions gaining the love of the loved one.
4. **Delight** – one exults in overrating the beauty and merit of the person he or she loves.

First, one admires the other person. Second, one acknowledges the pleasantness in having acquired the interest of a charming person. Third, hope emerges. In the fourth stage, one delights in overrating the beauty and the merit of the person whose love one hopes to win. This journey or crystallization process (shown above) was detailed by Stendhal on the back of a playing card, while speaking to Madame Gherardi, during his trip to Salzburg salt mine.

Psychologist Dorothy Tennov describes the process as a transformation in which the loved one's characteristics are crystallized via mental events and neurological reconfigurations such that attractive characteristics are exaggerated and unattractive characteristics are given little or no attention.[5] In other words, the attractive forces are given reign while the repulsive forces are sublimated. She uses this basis for her description of a *limerent object*, related to the concept of limerence.[6]

In modern terms, we can quantify and explain mental crystallization using a number of exacting perspectives, namely psychology, neurochemistry, and chemical thermodynamics. In psychology, we can discuss characteristic behavioral changes.

In neurochemistry, we can measure anatomical, neurochemical, and neurotransmitter changes.

In chemical thermodynamics, we can quantify the mental reaction process of crystallization of a new love in terms of entropy changes [3.10]. Specifically, for those people who we are mentally favored towards, such that the organizational effect of the neurological combination would result to lower the free energy of the system, the energy drive associated with the entropy of formation ΔS_F, would instill an *entropic visual enhancement*, in which the perceptual measure of that person's physical attractiveness would increase significantly. Conversely, for those people who we are not energetically favored towards, an *entropic visual de-enhancement* would occur in which the perceptual measure of that person's physical attractiveness would decrease significantly. In other words, after meeting someone and getting to know details about his or her person, they will momentarily begin to perceptually transform into a greater or lesser beauty due to energy-use affects in the system.

The 2001 romantic comedy film *Shallow Hal* starring Gwyneth Paltrow, Jack Black, and Jason Alexander captures the visual essence of this process beautifully.[7] In the movie, people in possession of entropy qualities of value, such as those listed below, affect those people they interact with to cause or mediate a basic neurological change in the perceptual measure of their visual attractiveness for the better.

Neurological Attraction Attribute	Symbol
Personality, Social Graces, Character & Dependability	S_P
Occupation, Possessions, or Money	S_O
Information, **I**ntelligence, Education, or Knowledge	S_I
Status or Prestige	S_S
Inner **N**ature, Values & Ambition	S_N

Likewise, those not in possession of entropy qualities of value, e.g. someone with a decrepit inner nature, affect those people they interact with to cause or mediate a basic neurological change in the perceptual measure of their visual attractiveness for the worse. Thermodynamically, these entropy qualities of value are defined by the following expression:

$$S = S_P + S_O + S_I + S_S + S_N \qquad [9.5]$$

This expression can then be substituted appropriately into the combined law of thermodynamics [4.27] so to account for changes in the Gibbs free energy ΔG in the

working system related to organization and dissipation. To clarify, [9.5] is modeled similar to the standard entropy summation formula for molecules in an ideal gas:

$$S = S_T + S_R + S_V + S_E \qquad [15.1]$$

where T = *translational entropy*, R = *rotational entropy*, V = *vibrational entropy*, and E = *electronic entropy*.[137] This model was originated by the work of Clausius who showed that not only can energy (or entropy) of a system of dynamic molecules be found in translational motion, but in other kinetic energy modes such as rotational motion. Thus, in human molecular systems, [9.5], as a first approximation, quantifies the entropy (organization energy) of human molecules in substrate-attached reactive (mate-selection) systems.

In social psychological terms, we can further quantify the crystallization process of love. In a general, we know that 85 percent people, at some point or another, will reproduce during his or her life.[8] Not all of these people, however, will fall in love. Estimates vary, but most generally indicate that 20 to 30 percent of people will fall not just in love, but *in love at first sight,* at some point during his or her life. In addition, according to Earl Naumann, author of the 2004 book *Love at First Sight*, wherein he interviewed and surveyed 1,500 individuals of all races, religions and backgrounds across America, we know that the phenomenon of love at first sight is not a rare experience. In his interviews, Naumann examined the influence of three categories of characteristics that attract people: physical traits, personality, and career or achievements. Naumann theorizes that if a person believes in love at first sight, that there is a roughly 60 percent chance it will happen to them. He arrived at this conclusion by noting that nearly 66 of the population believes in love at first sight, that of the of the believers, more than half have experienced it, that 55 percent of those who experienced it married the object of their affection, and that 75 of these married couples stayed married.[9]

Similarly, over the years, American social psychiatrist Arthur Aron, who runs an interpersonal relationship lab at the State University of New York at Stony Brook, has been exploring the dynamics of what exactly happens when two people are falling in love. Aron's research centers on the self-expansion model of motivation and cognition in personal relationships. His major current research programs focus on: (a) the cognitive overlap of self and other in close relationships, (b) how shared participation in novel and arousing activities can enhance relationship quality, (c) the role of friendship with members of ethnic outgroups in reducing intergroup prejudice, and (d) identify the neural circuits engaged by relationship-relevant cognitions and emotions.[10]

What motivates people to seek out love, according to Aron, is 'our primary motivation as human beings is to expand the self and to increase our abilities and our effectiveness' and furthermore 'one of the ways we accomplish this is through our

relationships with other people.' Likewise, in the process of love, according Aron, 'we fall in love with a person that we find attractive and appropriate for us, but also someone who demonstrates that they are attracted to us.' Similarly, in terms of percentage of people who fall in love at first sight Aron finds that 'contrary to what most people think, the statistics show that most people fall in love with someone that they have known for a while. People only report falling in love quickly about 33 to 40 percent of the time.'[11]

Similarly, in terms of love and pregnancy, when polled, those who create a child will freely admit to not being the same person they were before the birth of their first child; in other words 'it changes you'. Chemically speaking, this period of change is the 'transition state' in which one's molecular structure becomes reconfigured. In particular, scientists have shown that a person in love has vastly different neurological arrangements than as compared to the same person before he or she was in love.[12] Neumann, for instance, finds that 'being *in love* is an ongoing event, evolving, and changing over time', whereas '*falling in love* is a more discreet event'.

Below, as determined via measured blood flow levels, are those specific areas of central nervous system that become active or inactive during each respective phase of the transition state:

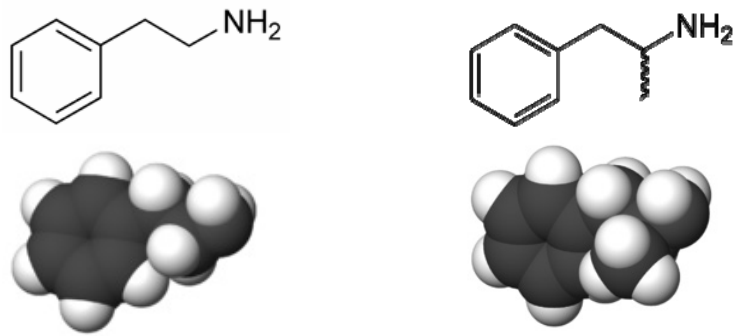
Before LOVE	7-months in LOVE	2.3 years in LOVE
Inactive	Caudate Nucleus*	Caudate Nucleus*
Inactive	Septum Pellucidum	Anterior Cingulate Cortex*
Inactive	Ventral Tegmental Area	Insular Cortex*

In this manner, specific brain regions 'work' to re-configure themselves before, during, and then after the transition phase of the typical human reproductive reaction. In general, whenever there is increased blood flow to any body part, it usually implies 'growth'; conversely, when decreased blood flow accrues it typically implies 'atrophy'.

Hence, perceptual crystallizations, i.e. love-related neuroanatomical changes, likewise, can be quantified in terms of free energy changes. In the 2006 article 'A Free Energy Principle for the Brain', for example, neuroscientists Karl Friston, James Kilner, and Lee Harrison argue that perceptual processes are an aspect of emergent behaviors that conform to a free energy principle. The free energy principle they consider measures the differences between the probability distribution of environmental quantities that act on the system and an arbitrary distribution encoded by its configuration. The system, according to these researchers, 'can minimize free energy by changing its configuration to affect the way it samples the

environment or change the distribution it encodes.' Likewise, they argue that 'these changes correspond to action and perception respectively and lead to an adaptive exchange with the environment that is characteristic of biological systems.'[13]

In sum, each neuroanatomical structure and free energy change associated with that structure can be quantified. The *caudate nucleus* motivates people to formulate and carry out goal specific plans and objectives, so to obtain desired rewards. The *septum pellucidum* releases the same amphetamine-like neurochemicals found in chocolate, such as phenylethylamine, thus acting as a mental upper control center:



Phenethylamine $C_8H_{11}N$ Amphetamine $C_9H_{13}N$

The *ventral tegmental area* releases dopamine, a motivation neurotransmitter, which operates to focus attention, and to abound a person with energy. The *anterior cingulate cortex* is an area where emotions, attention, and working memory interact—it allows one to interpret other people's emotions. The *insular cortex* is where we register 'butterflies' in the stomach. Also, those structures, shown above with an asterisk, are the same structures that become active when a person injects himself or herself with cocaine or opioids.[14] Essentially, being well into a successful reaction phase of love, 2.3 years plus, is chemically similar to doing a 'line' but without the side effects.

To recap, during the transition state of the chemical reaction, a person becomes neurologically-transformed into something new: the stable human molecular bonded, married, or united couple AB; and this process, on average, results to release a great deal of free energy G, i.e. energy from a chemical reaction available to do useful work. Also, negative changes in free energy ΔG correspond to successful bonds; and positive changes in free energy correspond to unsuccessful bonds.

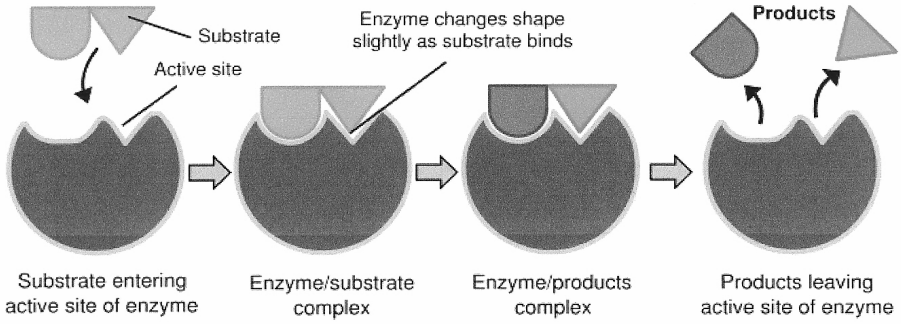
We note that for the last 100-years, or so, people have been intuitively well aware of this transition-state or molecular-transformation description behind human bonding. In the early 20th century, the famed Swiss analytical psychologist Carl Jung stated 'the meeting of two personalities is like the contact of two chemical substances; if there is any reaction, both are transformed.' As another example, human mating-behavior researcher Dorothy Tennov, in her 1979 book: *Love and*

Limerence, interviewed one newly love-smitten fellow who states: 'my whole world had been completely *transformed*. It had a new center—and that center was Marilyn.' Hence, to fall in love—is to be 'transformed'. As such, the latter state of love as contrasted with the initial state are two entirely different energetic configurations, the latter being the more stable of the two, and the difference in energy between the two states being the amount of energy released over the course of the reaction. Here we find connection between love, energy, neuroanatomy, and chemistry.

Template theory

In human chemistry, *template theory* postulates that during the reaction course of human molecular development, beginning particular at the point of gametic fusion (conception) and into the early years of life, people will neurologically template off their surroundings, in such a manner so to emulate, via the construction of mental reaction templates or *behavioral templates*, those attachment behaviors found to be desirable and to negate or deter those attachment behaviors found to be repulsive.

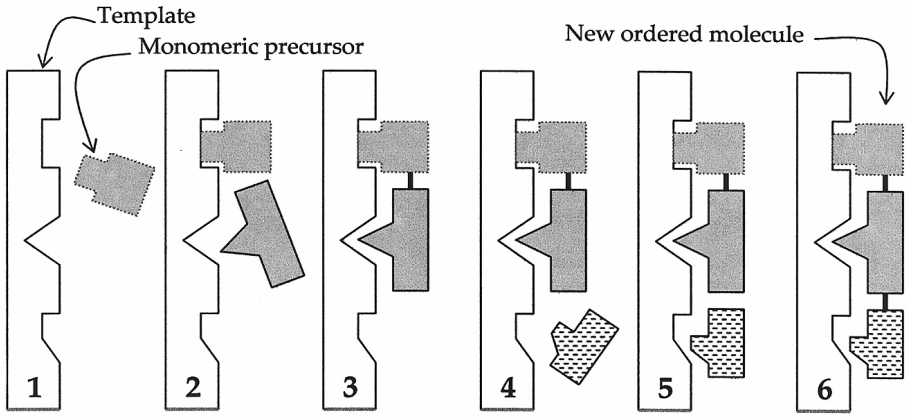
In chemistry and genetics, by comparison, a *template* is defined as a molecule, such as DNA, that serves as a pattern for the generation of another macromolecule, such as messenger RNA.[15] In psychology, it is known that people 'template' behaviors off of people they admire, desire, or are attracted to. Hence, by logical extrapolation, it is reasonable to assume that over the life reaction course of a human, he or she builds themselves off the interactions they encounter, that these basic templating processes actuate in the central nervous system, and that neuro-template models are similar to basic protein-enzyme or RNA-DNA template models in conception.



The original template model, shown above, was the famous 1894 'Lock and Key' molecule bonding theory, proposed by German chemist Emil Fischer. According to this theory, molecules fit together according to complementary geometric shape. Enzymes, for example, are very specific, and Fischer suggested that this was because both the enzyme and the substrate possess specific complementary geometric shapes that fit exactly into one another.[16] This is often referred to as the lock and key model,

owing to the conception that the substrate-molecule is said to 'lock' into the 'key' binding site of the enzyme-molecule. In this manner, an enzyme combines with its substrate(s) to form a short-lived enzyme-substrate complex.

The concept of 'template surfaces' was conceived of in the 1940s, by luminaries such as Linus Pauling and Max Delbrück, in efforts to understand how *proteins*, i.e. molecules comprised of connected and folded chains of amino acid, are made.[17] In the basic template model, molecular units, called mono-meric precursors, one-by-one, are attracted to a geometric template surface. Once attached, they are molded or atomically shaped into a new unit. In the final stage of the shaping process, the newly shaped molecule detaches and goes off on its own. The basic template model, in which a specific polymeric molecule unit is constructed on a three-dimensional surface, is shown below:



Here, first each monomeric precursor, e.g. an amino acid, is drawn to the contours of template surface by intermolecular forces. Next, after two adjacent monomeric units become fixated, a covalent bond '–' forms, with the help of a polymerizing enzyme, between each unit, thus acting to build a polymeric unit, i.e. grown molecule. Once formed, the fully ordered unit will then detach from the template to serve its function elsewhere, i.e. to find a more free-energy lowering reaction somewhere else.

This basic model arose in the early 20th century, after it was found that proteins possess unique amino acid sequences; this demanded the existence of specific templates on which their amino acid building blocks are laid down[18] These templates, it was found, had to be macromolecules, at least as large as the polypeptide products. By studying the nature of the chemical forces that attract small molecules to their templates, it was expected that these forces would be the same as those that attract substrates to their enzymes.[19] Since these forces operate only over small distances, templates can order small molecules only when they are in close contact. During these years, it was correctly assumed that the specific *attracting regions* of the template would be in the same size range as the amino acid side groups in the protein products.[18]

This model, coincidently, is the same as Konrad Lorenz's 'imprinting' in which the young infants are instinctively, i.e. electromagnetically drawn, to the attracting regions, i.e. the sensory stimulus of the parental substrate, and are then hence forth molded and shaped behaviorally off that first template and other templates to follow. In adult life, a woman may specifically attach to the attracting region of a man's personality, ambition, wealth, or occupation. Likewise, a man may specifically attach to the attracting region of a woman's body part, accomplishment, intelligence, or sense of humor, and in each case be molded off that template (person).

The first human template is the substrate of the maternal-infant bond. The mother-infant bond, according to American love-relationship researcher Anthony Walsh, is 'the template for all other bonds.' Moreover, according to Walsh, 'the infant's mother programs its brain in ways that will determine how it will live the rest of its life.'[20]

The embryo human molecule will first be intrauterine for 10 lunar months and then, on average, will spend the first 3 years of life attached in maternal-infant bond relationship to which it will template off of. Other early templates include paternal-child bonds, sibling-sibling bonds, friendship bonds, distal family bonds, imaginary bonds, or conceptual bonds lived vicariously through books, television, movies, etc. In early youth and into adolescence, these precursory templates will serve as models by which the human molecule will use to begin to test out teenage romantic-sexual templates, as are formed more vigorously in adult reaction life.

To elaborate, according to mate-selection biologist Timothy Perper, with respect to male-female interactions, or in terms of homo-, bi-, or cross-sexual relationships, *templates* represent a person's indwelling images of potential sexual partners.[21] It is known, for instance, that as the number of older brothers (sibling templates) one has increases, so does that chance that he will be homosexually bonded later in life.

In all romantic relationship terms, people will naturally template off each reaction collision process. If, for example, a human molecule finds and attaches to his or her first love, but then, for whatever reason, it doesn't work out, that detached human molecule will naturally search for and seek out a second reaction love in possession of similar, but distinctly different, template properties.

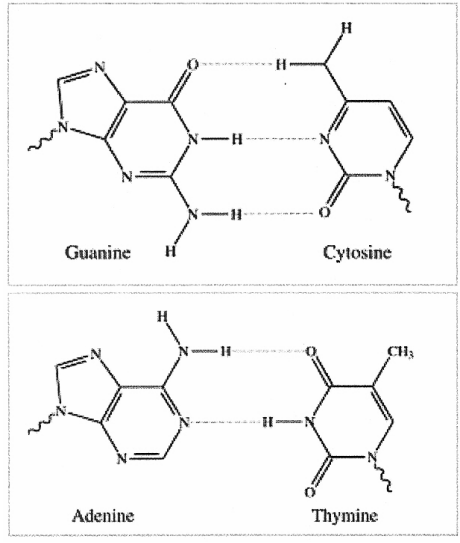
Likewise, according to thermo-economist Jing Chen, according to the second law of thermodynamics 'a random action generally costs more than it gains.' Thus, 'to concentrate actions into profitable ones, we like animals, often learn from the experience of successful individuals and *copy* their behavior.' In general, according to Chen, it is costly and impossible to repeat all of the experiences and mistakes that are possible; therefore, we accept certain modes of behavior demonstrated by others without completely investigating the reasons behind them.[22] Copying the behaviors of others directly is much easier than trial and error and often more efficient.

A basic model of this molecular behavior copying process is *DNA replication* or 'DNA synthesis', which is the process of copying a double-stranded DNA molecule.

This process is important in all known forms of life. As each DNA strand holds the same genetic information, both strands can serve as templates for the reproduction of the opposite strand.[23] The template strand is preserved in its entirety and the new strand is assembled from nucleotides. This process is called *semiconservative replication*.[24] The resulting double-stranded DNA molecules are identical; proofreading and error-checking mechanisms exist to ensure near perfect fidelity.

In genetics, to compare another similar template model, *transcription* is the process of molecular templating and is the act through which a DNA sequence is enzymatically copied by an RNA polymerase to produce a complementary RNA.[25] In other words, it is the transfer of genetic information from DNA into RNA. In the case of protein-encoding DNA, transcription is the beginning of the process that ultimately leads to the *translation*, i.e. the process of protein biosynthesis in which cells build protein molecules, of the genetic code, via the mRNA intermediate, into a functional peptide or protein.[26] The stretch of DNA that is transcribed into an RNA molecule is called *transcription unit*. Transcription has some proofreading mechanisms, but they are fewer and less effective than the controls for DNA; therefore, transcription has a lower copying fidelity than DNA replication. The molecules that mediate the templating process are called *base pairs* and in DNA come in four varieties, namely guanine, cytosine, adenine, and thymine.

In transcription, the template reaction attachment patterns that result are due to the geometrical orientations, i.e. entropic energy bonding tendencies, between the four element molecule *guanine* [$C_5H_5N_5O$], which triple-bonds to the four element molecule *cytosine* [$C_4H_5N_3O$], i.e. [$C_5H_5N_5O$]≡[$C_4H_5N_3O$], and the three element molecule *adenine* [$C_5H_5N_5$], which double-bonds to the four element molecule *thymine* [$C_5H_6N_2O_2$], i.e. [$C_5H_5N_5$]=[$C_5H_6N_2O_2$], as shown below:



DNA base pairs: G≡C (top) and A=T (bottom)

In human templating terms, a newborn infant, i.e. a newly forming twenty-six-element molecule, in a similar manner, will template off his or her parental substrate using the bonding surface of those thermodynamic ties.[27] From this base, likewise, a person will then template off the thermodynamic ties of friends, mates, associates, acquaintances, and other personalities, such as those found in stories or movies, etc.

A *gene*, to note, is a sequence of DNA that contains genetic information and can influence the phenotype of an organism.[28] Within a gene, the sequence of bases along a DNA strand defines a messenger RNA sequence, which then defines a protein sequence. The relationship between the nucleotide sequences of genes and the amino-acid sequences of proteins is determined by the rules of translation, known collectively as the genetic code. The genetic code consists of three-letter 'words' called *codons* formed or templated from a sequence of three nucleotides (e.g. ACT, CAG, TTT).[29]

In transcription, the codons of a gene are copied into messenger RNA by RNA polymerase.[30] This RNA copy is then decoded by a ribosome that reads the RNA sequence by base-pairing the messenger RNA to transfer RNA, which carries amino acids. Since there are 4 bases in 3-letter combinations, there are 64 possible codons (4^3 combinations). These encode the twenty standard amino acids, giving most amino acids more than one possible codon.[31] There are also three 'stop' or 'nonsense' codons signifying the end of the coding region; these are the TAA, TGA and TAG codons.[29]

In sum, similar to how the transfer of genetic information can flow from DNA into RNA via templating, human molecular template theory postulates that infantile human molecules are formed or molded, based on experienced enthalpic and entropic bonding interactions, off the human molecular templates and environmental constructs found in his or her immediate growing or evolving environment from inception forward. Moreover, it is argued that templating is a life-long process.

Child psychologist John Bowlby, who in the early 1940s began to expound on the hypothesis that early environmental influence, particularly in regards to early bonding interactions, plays a major role in the later procurement patterns of bonds acquired in adult life, was one of the earliest researchers to put forward a semblance of human molecular template theory. He argued that newborn humans ‘attach’ to the life of the parental figure and that this dynamic attachment molds the person. This theory was later expanded on by the work of Bowlby’s associate Mary Ainsworth who contributed to the concept of the attachment figure as a *secure base* from which the infant can explore the world.[32]

To elaborate, many patterns of disturbed family functioning and personality development, according to Bowlby, can be understood in terms of the pathological development of ‘attachment behavior’, stemming from aberrant bonding interactions experienced during the first fifteen years of life, i.e. bad templating. A well-known example is the emotionally detached individual who is incapable of maintaining a

stable affectional bond with anyone. The typical history for such individuals is one of prolonged deprivation (no-templating) of maternal care during the earliest years of life, usually combined with later rejection and or threats of rejection by parents or foster parents.

In order to explain these patterns and to further explain why individuals of different sorts should continue to exhibit the characteristics described long after they grown up, Bowlby postulated that: 'whatever representational models of *attachment figures* and of self an individual builds during his or her childhood and adolescence, tend to persist relatively unchanged into and throughout adult life.' As a result, according to Bowlby, he or she tends to assimilate any new person with whom he or she may form a bond such as a spouse or child, or employer or therapist, to an existing model, and often to continue to do so despite repeated evidence that the model is or may be inappropriate.

From a neurological attachment theory point of view, according to American neuropsychologist Allan Schore, Bowlby 'calls for a deeper explanation of the fundamental ontogenetic mechanism by which an immature organism is critically shaped by it primordial relationship with a mature adult member of its species, i.e. for more extensive studies of how an attachment bond forms between infant and mother.[33] Similarly, according to Lewis, Amini, and Lannon's 2000 *General Theory of Love*, the wordless ties each of us has to others 'determine our mood, stabilize and maintain our health, and change the structure of our brains, so that, in a very real sense, who we are and who we become depend on whom we love.'[34]

Likewise, American bonding researchers Stephen Bank and Michael Kahn argue that siblings are central molding factor involved in the templating of a person, more so than that of parental influence. There view is such that 'brothers and sisters, whether the relationship has been contentious or calm, satisfying or frustrating, filled with conflict or deeply comforting, can provide the touchstones and *templates* which mold each other's lives.'[35]

In sum, human molecular template theory holds that, to a certain extent, humans are formed and templated off the people, good or bad, they meet in life. The model also posits that there exist neuro-template structures in the mind that mediate the process of psychological attachment templating. In future research, further study of pre-existing template models will invariably yield useful views on more accurate models of human reaction life.

One topic we have yet to discuss fully is homosexual, bisexual, or transgender chemistry. Inherently, there is no real theoretical difference between homosexual, bisexual, or transgender varieties of chemistry and heterosexual chemistry. In actual practice, however, it is a minority variation of reaction life. Conservative estimates indicate that 3 to 4 percent of men and 1 percent of women have homosexual mate preferences.[36] Certainly there are genetic, hormonal, and neurochemical differences between homosexual and heterosexual human molecules, but the reaction is still a

chemical reaction and the laws of quantum chemistry, chemical thermodynamics, and quantum electrodynamics are still absolute.

LGBT/Queer chemistry

In human chemistry, *LGBT chemistry* or 'queer chemistry' is the study of reactions of lesbian, gay, bisexual, transgender, questioning, pansexual, bi-curious, or asexual, etc., human molecules that are related to or characterized by a tendency to direct sexual desire and attachment behaviors towards another of the same sex, alternate sex, or one who is non-sexual, and other variations, etc., respectively.[37]

As to terminology, LGBT (or GLBT) is an abbreviation used as a collective term to refer to Lesbian, Gay, Bisexual, and Transgender people. It is an adaption of the abbreviation LGB. While still controversial, it is considered less controversial than *queer* and is more comprehensive than *homosexual* or simply *gay*. The acronym GLBT is sometimes used in the United States and commonly in Australia, but to a lesser extent elsewhere. *LGBT*, as of 2005, has become so mainstream that it has been adopted by the majority of lesbian, gay, bisexual, and transgender community centers and the LGBT press in most English-speaking countries.[38]

Beyond these standard abbreviations, many variants exist. The most commonly used involve adding a *Q* for *queer* or *questioning*, while some variants, in fact, use *two* Qs to represent *both* of these groups, an *A* for asexual or allies (and sometimes *S* for *straight ally*), an *I* for *intersex*, or a *P* for *pansexual* or *polyamorous*. Some even add an *O* for *omnisexual* or *other*.[39] Beyond these diverse labels, others will self-identify as 'other' and will qualify with statements such as: 'dyke…but also gender queer', 'dyke with FTM (female-to-male) partner, 'open minded', 'queer and trans', 'queer trans fag', 'queer/bi-dyke', or 'queer/trans', etc.[40]

Homosexuality is a sexual orientation and it is defined as romantic attraction and or sexual interaction between individuals of the same sex. In modern use, the adjective *homosexual* is used for intimate relationships and or sexual relations between people of the same sex, who may or may not identify themselves as gay or lesbian. Homosexuality, as an identifier, is usually contrasted with heterosexuality and bisexuality. The term *gay* is used predominantly to refer to self-identified homosexual people of either sex. *Lesbian* is a gender-specific term that is only used for self-identified homosexual females.[38]

To give an idea of the prominence of queer chemist and reactions, according to a recent Nation Survey of Family Growth, 4.1 percent of American men and women aged 18-45 identify as gay, lesbian, or bisexual. In terms of numbers, approximately 8.8 million adults are gay, lesbian, or bisexual in the United States.[41] In more detail, the following chart shows the top 10 U.S. cities within city limits with the highest GLB population as a percentage of total residents.[41]

Rank	City	Percentage Population	GLB Population
1	San Francisco	**15.4%**	94,234
2	Seattle	**12.9%**	57,993
3	Atlanta	**12.8%**	39,805
4	Minneapolis	**12.5%**	34,295
5	Boston	**12.3%**	50,540
6	Sacramento	**9.8%**	32,108
7	Portland	**8.8%**	35,413
8	Denver	**8.2%**	33,698
9	Washington	**8.1%**	32,599
10	Orlando	**7.7%**	12,508

Numbers aside, queer chemistry is no different from that of straight chemistry, i.e. chemistry is chemistry. Yet, due to a two-century long misunderstanding of the basics of human chemical nature, LBGT chemistry has been practically shunted off the investigative slate of scientific study. To elaborate, in the U.S., for instance, the year 2003 marked a milestone in extending legal rights to homosexuals in North America. In June 2003, the Supreme Court of the United States struck down laws that criminalized homosexual behavior.[42] In other words, historically, homosexual chemistry has been viewed as an illegal type of reaction. In chemistry, however, there is no such thing as an *illegal reaction*; a reaction is what it is. The following equation, to clarify, is the basic male homosexual bonding chemical reaction:

$$Mx_1 + Mx_2 \rightarrow Mx_1Mx_2 \qquad [15.2]$$

Similarly, below is the female homosexual bonding chemical reaction:

$$Fy_1 + Fy_2 \rightarrow Fy_1Fy_2 \qquad [15.3]$$

Other possible reaction variations include bisexual reactions, transgender reactions, heterosexual-homosexual reactions, transgender-bisexual reactions, and numerous other possible variations, etc.

The area of LBGT/queer chemistry that will differ significantly in homosexual-type bondings, A≡A, as contrasted with heterosexual bondings, A≡B, is that the stability and composition of the thermodynamic ties in the dodecabond model will not be the same. The enthalpy of age component of bonding H_{AGE}, for instance, in queer tie bondings, will tend to actuate such that pairs will be closer in age as contrasted with straight tie bondings in which pairs will be dissimilar in age, more so

in second and third marriage reactions. This is due to similarities in fertility curves in homosexual pairs as contrasted with dissimilarities in fertility curves for heterosexual pairs. In other words, two men will ripen at the same rate whereas a man and woman will ripen at different rates. Likewise, tie components such as enthalpy of sexuality H_X and entropy of occupation S_O will be unique in queer-tie bondings. Testosterone-to-estrogen ratios will be slightly different in queer-pairs as compared to straight-pairs, who will have differing average hormonal ratios. There may be, to elaborate further, less partner pressure on gay or lesbian men and women to excel in areas of career advancement as compared to straight men and women, whereas there may be more pressure in other areas. This is an area of further research.

These bonding tie distinctions are clear. Yet, in spite of the obvious fact that homosexual relationships are chemical reactions, some maintain that the prevalence of homosexual love and bonding is a mystery. Some maintain that homosexuality has no evolutionary purpose or that it is a biochemical anomaly that occurs during fetal development.[43] These views, however, are outdated. In other words, the older evolution views, based on an assimilation of Darwin's 1859 theory of natural selection and Mendel's 1865 theory of genetic inheritance, are such that some contend that the purpose of life is to reproduce effectively so to pass on fervent genes into the next generation. In this perspective, one may erroneously argue that homosexual chemistry does not have a place in the Darwin-Mendel scheme.

In 1991, for instance, human relationship researcher Anthony Walsh, in his *The Science of Love,* states 'given that nature's aim is the survival of the species, it is puzzling that homosexuality has become an established pattern in the sexual repertory of human beings.' The error here is that nature's aim is not survival of the species. This is not a concept found in chemistry textbooks. In chemical systems, natures aim is to react and evolve towards quantum electronic stability. In biospheric systems, this correlates to the effect that nature's aim is towards the minimization of the Gibbs free energy of each evolving subsystem.

In modern terms, we know that life is a series of evolving chemical reactions, driven by heat energy, emanating from the thermonuclear reactions internal to the sun. As such, humans are molecules found in thermodynamic systems.[44] Life then, in thermodynamic systems, will be dictated by the laws of thermodynamics. In isothermal, isobaric thermodynamic systems, such as on earth, these laws dictate that within each work cycle, the system will evolve such that there will be a decrease in the Gibbs free energy each system.[45] This tendency is quantitatively defined by the combined law of thermodynamics. In each partitioned thermodynamic system, each species, in accordance with [4.27], will react and evolve with the general purpose to decrease its chemical potential.[46] As such, for some that purpose will involve reproduction, for others the purpose will be different.

Beyond this basic platform, there are numerous ways to study and understand homosexual chemistry and bonding tendencies. One is through the perspective of *template theory*, namely that each human molecule is conceived with a distinct atomic structure, and then develops in a system, first intrauterine, then intra-family, and then intra-society, each of which can be thought of as a molecular attachment template environment. Through development then, each human molecule, on average, will hone their atomic structure so to find optimal stability in his or her system. In addition, as studies have shown, bonding behavior is a skill that is learned in early development and influenced by the system.[47]

One of the earliest studies in the area of the prenatal origins of homosexuality was done beginning in the 1960s and into the 70s at the laboratory of East German endocrinologist Gunter Dorner. By experimentally manipulating hormone levels during the critical sex-differentiating period among rats, Dorner found that, as adults, male rats deprived of androgen and female rats exposed to excess androgen were preferentially excited by members of their own sex.[48] In other words, the social, personal, and mental states and stabilities of the mother during pregnancy, will influence the chemical nature of the intrauterine environment of the fetus, which will have a role in determining its later sexual orientation.

Recent studies, as mentioned, have tied a correlation between the number of older brothers a man has and his likelihood of being homosexual, reporting that each older brother increases the odds of being gay by 33 percent.[49] This is now 'one of the most reliable epidemiological variables ever identified in the study of sexual orientation.'[50] To explain this finding, it has been proposed that male fetuses provoke a maternal immune reaction that becomes stronger with each successive male fetus.[49] Male fetuses produce H-Y antigens which are 'almost certainly' involved in the sexual differentiation of vertebrates.[49] It is this antigen which maternal H-Y antibodies are proposed to both react to and remember. Successive male fetuses are then attacked by H-Y antibodies, which somehow decrease the ability of H-Y antigens to perform their usual function in brain masculinization. This is now known as the *fraternal birth order effect*.

In a recent 2006 study, which compared the effects of being raised with older 'brothers' and having biological older brothers, findings indicated that there is a link to homosexuality only if the older brothers are biologically related; even when they were not raised together.[51] Interestingly, this relation seems to hold only for right-handed males.[52] Moreover, the fraternal birth order effect only accounts for a maximum of one seventh of the prevalence of homosexuality in men. There seems to be no effect on sexual orientation in women, and no effect of the number of older sisters. In the 2000 *Archives of Sexual Behavior* article 'homosexuality, birth order, and evolution: toward an equilibrium reproductive economics of homosexuality, author Edward Miller suggests that the birth order effect on homosexuality may be a by-product of an evolved, biological mechanism that shifts personality toward the

feminine direction in laterborn sons. This would have the consequence of reducing the probability of these sons engaging in unproductive competition with each other.[53]

Likewise, when a person grows he or she will develop a unique subliminal guide to the ideal partner, a 'love map', a term coined by sexologist John Money.[54] In each system as a person develops, a neuromap will record whatever it is that one uniquely finds enticing, exiting, disturbing, etc., e.g. small feet, curly hair, thinner people, a fireman's uniform, a doctor's stethoscope, etc.[43] All the information gathered while growing is imprinted in the brain's circuitry by adolescence. In the years to follow, each person will tend to match to other people based on their neuromap. In this manner, 2 to 4 percentage of people will develop homosexual lovemaps.[55]

Another difference between homosexual human molecules (homo-molecules) and heterosexual human molecules (hetero-molecules) are scent attractors as well as brain structure differences.[56] Over the last decade, beginning with Swiss zoologist Claus Wedekind's 1995 scent research on MHC-mate preferences, studies have suggested that people might be using odor cues associated with the immune system to select mates who are not closely related to themselves.[57] Using a brain imaging technique, Swedish researchers have shown that homosexual and heterosexual males' brains respond differently to two odors that may be involved in sexual arousal, and that the homosexual men respond in the same way as heterosexual women. According to researchers, these findings suggest a possible role for human pheromones in the biological basis of sexual orientation.[58]

Specifically, in 2005, physician Ivanka Savic and colleagues at the Karolinska Institute in Stockholm studied the two chemicals, one a testosterone derivative produced in men's sweat and two an estrogen-like compound in women's urine, both of which have long been suspected of being pheromones. They found that the estrogen-like compound, though it activated the usual smell-related regions in women, lighted up the hypothalamus in men. This is a region in the central base of the brain that governs sexual behavior and, through its control of the pituitary gland lying just beneath it, the hormonal state of the body. The male sweat chemical, on the other hand, did just the opposite; it activated mostly the hypothalamus in women and the smell-related regions in men. These findings are similar to a 1991 report by physician Simon LeVay that a small region of the hypothalamus is twice as large in straight men as in women or gay men.[59]

In any event, these two chemicals seem to be leading a double life, playing the role of odor with one sex and of pheromone with another. Savic also repeated the experiment but with the addition of gay men as a third group. The gay men responded to the two chemicals in the same way as did women, Savic reports, as if the hypothalamus's response is determined not by biological sex but by the owner's sexual orientation.[58]

Similarly, we know that pheromones can trigger changes in neurotransmitter levels. Added to this, it is known that high levels of serotonin promote selectivity in

mates, namely same species and heterosexual choice; whereas low levels promote indiscriminate sexual choice of partner and gender.[60] Likewise, lower levels of serotonin in females will cause them to mount other females and smaller males and behave more like males.[60] Hence, pheromones and neurochemicals may work in coordination to facilitate queer chemistry and bonding.

In terms of genetics and homosexuality, in general, twin and family tree studies are based on the principle that genetically-influenced traits run in families. The first modern study of patterns of homosexuality within families was published in 1985 by Richard Pillard and James Weinrich of Boston University.[61] Since then many other systematic studies of twins and siblings of gay men and lesbians have confirmed the initial results. The first pooled data for men showed that about 57% of identical twins, 24% of fraternal twins and 13% of brothers of gay men are also gay. For women, approximately 50% of identical twins, 16% of fraternal twins and 13% of sisters of lesbians are also lesbian. Michael Bailey of Northwestern University estimates that the overall heritability of sexual orientation is about 53% for men and 52% for women.[61] One of the latest evaluations, based on the sexual orientation in a U.S. national sample of twin and non-twin sibling pairs, confirmed that resemblance for sexual orientation was greater in the identical twins than in the fraternal twins and that sexual orientation is 'substantially influenced by genetic factors.[62]

In terms of chromosomes and homosexuality, the a gene on the X chromosome called Xq28 is the candidate region for gay mating behavior.[63] In 1993, American biochemist Dean Hamer announced that he had found a gene on the X chromosome that had a powerful influence on sexual orientation, or, as the media quickly called it, 'a gay gene'.[64] To find this, Hamer and his colleagues interviewed 110 families with gay male members and noticed something unusual. Homosexuality seemed to run in the female line. If a man was gay, the most likely other member of the previous generation to be gay was not his father but his mother's brother.[63]

This immediately suggested to Hamer that the gay gene might be on the X chromosome, the only set of nuclear genes a man inherits exclusively from his mother. Hence, after comparing genetic markers between gay and straight men from his sample he found a candidate region in Xq28, the tip of the long arm of the chromosome.[65] He found that gay men share the same version of this marker seventy-five percent of the time; straight men shared a different version of the marker seventy-five percent of the time.[63] The a 1993 study, Hamer examined 114 families of gay men and found increased rates of homosexuality among maternal uncles and cousins, but not among paternal relatives. Genetic linkage was studied in 40 of the families, in which there were two gay brothers. A correlation to Xq28 and other microsatellite markers was found in approximately 64% of the cases.[66]

In 1999, Hamer's results were disputed by George Rice at the University of Western Ontario. Studying 52 pairs of gay brothers, Rice and his associates found no statistically significant linkage in alleles and haplotypes and concluded against an X-

linked male homosexuality gene.[67] When the refuting study was published in *Science*, Hamer disputed it, standing by his original results.[68] In any event, genetic science is in its infancy; future studies will likely find clarification on this matter.

Recently, in online matching, two of the major dating services, *eHarmony.com* and *chemistry.com*, have been butting heads on the issue of homosexual chemistry and matchmaking. Specifically, in May of '07 *chemistry.com* took on *eHarmony* with ads featuring men and women wondering why their applications were rejected by *eHarmony*. The ads note that *eHarmony* has rejected more than 1 million people who are looking for love. In one ad, a young man flips through what looks like a Playboy magazine, kind of bored, and then he says: 'Nope,' sighing, 'still gay.' And then he's superimposed with a big red 'Rejected by eHarmony' stamp.[69]

eHarmony tried to get the commercials pulled. *eHarmony* acknowledges that it has, in fact, rejected 1 million people. Marrieds, under 21s, inconsistent answerers, those under 60 who've been married more than four times, anyone who might suffer from severe depression, and gay people are turned away.[70] In efforts to defend himself, eHarmony founder Neil Warren states *eHarmony* promotes heterosexual marriage, about which he has done extensive research. He says he does not know enough about gay and lesbian relationships to do same-sex matching. It 'calls for some very careful thinking. Very careful research.' He adds that same-sex marriage is illegal in most states. 'We don't really want to participate in something that's illegal.'[69]

To compound the issue, in June of '07 *eHarmony* was sued for refusing to offer its services to gays, lesbians and bisexuals. A lawsuit alleging discrimination based on sexual orientation was filed in Los Angeles Superior Court on behalf of Linda Carlson, who was denied access to *eHarmony* because she is gay. Lawyers bringing the action said they believed it was the first lawsuit of its kind against *eHarmony*, which has long rankled the gay community with its failure to offer a 'men seeking men' or 'women seeking women' option. They were seeking to make it a class action lawsuit on behalf of gays and lesbians denied access to the dating service.[71]

At *chemistry.com*, conversely, gay chemistry is taken at face value as reality and pairs are made according to queer matching algorithms, whatever they may be? In addition, according to *chemistry.com's* scientific advisor, anthropologist and love expert Helen Fisher, both gay and lesbian homosexuals face more turmoil than heterosexuals in the area of finding love.[72] Homosexuals, according to Fisher's surveys, have a higher incidence of lack of sleep, lack of appetite, and feelings of yearning to find an 'emotional tie' to someone who they could love. This is due in part to the barriers in today's society that make it more difficult for someone to find a loved one of the same sex.[72] In other words, queer bonding may be more difficult than straight bonding, owing to prevalent cultural ideals.

Müller dispersion forces

In social situations large numbers of people collect, e.g. a 100,000 or more people in a football stadium, social bonds become difficult to quantify due to the large number of human molecules involved. In these large aggregate situations, theorists often resort to the use of the term *social forces* to define an influence or authority that has an effect or control over other people and their actions.[73]

In 1922, for example, American sociologist Howard W. Odum, father of the noted energy ecologist Howard T. Odum, one of the founding fathers of ecology, author of 1971 book *Environment, Power, and Society,* founded the *Journal of Social Forces*, which from 1925 afterwards was published as *Social Forces*.[74] *Social Forces* currently is a social science academic journal published by University of North Carolina Press that concentrates on sociology but also addresses related problems within the fields of social psychology, anthropology, political science, history, and economics.[75] The Odum's define the concept of 'force', be it a social force, economic force, political force, or physical force, as a causal action.[76]

Indianapolis Motor Speedway, located in Speedway, Indiana, a separate town completely surrounded by Indianapolis, in the United States, is the second-oldest surviving automobile racing track in the world (after the Milwaukee Mile), having existed since 1909, and the original 'Speedway', the first racing facility historically to incorporate the word.[77] With a permanent seating capacity of over 257,000 people and infield seating that raises capacity still further to an approximate 400,000, it is the largest and highest-capacity sporting facility in history (by comparison, the world's largest soccer stadium seats 150,000 spectators).[78]

These types of social festivals are defined as large human molecular aggregates, comprised of socially affined molecules. The multiplier units for large molecular systems are as follows: da (deka-) 10^1, h (hecto-), 10^2, k (kilo-) 10^3, M (mega-) 10^6, G (giga-) 10^9, T (tera-) 10^{12}, P (peta-) 10^{15}, and E (exa-) 10^{18}, etc. Hence, for example, a social event comprised of 100,000+ people, would be termed a mega-molecular aggregate. To elaborate on this perspective, we ask must ask: which of the four fundamental forces, i.e. strong nuclear, weak nuclear, electromagnetic, or gravitational, functions to hold such ubiquitous aggregates together?

In human chemistry and human thermodynamics, these aggregate social forces are called *Müller dispersion forces*, defined as weak inter-human molecular forces due to quantum mechanical electrostatic attractions and repulsions related to subtle fluctuations in positions of valence shell sensory electrons.[79] These social dispersion forces are named after Venezuelan chemical engineer Erich Müller who in 1998, in an article entitled 'Human Societies: a Curious Application of Thermodynamics', first correctly defined humans to be analogous to molecules, then quantified inter human molecular love and hate in terms of basic thermodynamic pair bonds, and the lastly quantified social forces as a type of van der Waals dispersion force.[80] Müller

was not the first to suggest this type of theory, yet he was the first to state such an outline accurately, with examples, and in great detail, in terms of thermodynamic potentials and in quantum electromagnetic terms.

In 1873, as discussed, Dutch physical chemist Johannes van der Waals, building on the shoulders of those as Bernoulli, Clausius, and Maxwell, published a treatise in which he outlined a revolutionary theory concerning the mutual attractions, repulsions, and interactions of molecules in the gas phase and how variations of these attractions result to create density, pressure, and temperature variations. Van der Waals, like Maxwell, had originally been inspired towards the development of a theory of 'intermolecular forces', after he had read a popular 1857 treatise by Rudolf Clausius concerning the nature of the motion called heat.[81]

Van der Waals visualized that molecules in the gas phase move about freely occasionally interacting through impacts, that molecules in the liquid phase are regulated by stronger forces, that molecules in the solid amorphous state impede each other's motion owing to their close proximity, and that the crystalline state has a molecular behavior and motion unique to itself. On these views, van der Waals conceived of the idea that there are variations of mutual attractions and repulsions between molecules, a factor now defined as intermolecular forces, dispersion forces, or 'Van der Waals forces', characterized as weak yet defining social forces between molecues.[82]



Van der Waals force holding a gecko's feet to a glass wall

In current models, the Van der Waals force, for instance, is that force to which the gecko's climbing ability is attributed.[83] A gecko can hang on a glass surface using only one toe. Efforts continue to create a synthetic 'gecko tape' that exploits this knowledge. So far, research has produced some promising results; namely, early research yielded an adhesive tape product, which only obtains a fraction of the forces measured from the natural material.[84]

In chemistry, *intermolecular forces* are the forces of attraction and repulsion between molecules.[85] Molecular behavior depends to a great extent on the balance (or lack of it) of the forces that pull the molecules together, or push them apart.[85] In

small atomic and molecular systems, intermolecular forces become significant at molecular separations of about 1 nanometer or less, but are much weaker than the forces associated with chemical bonding.[86] In human molecular terms, according to American anthropologist Edward Hall's 1966 proxemics researcher, we have the following data for social and public distances at which we might expect social inter-human molecular forces to come into action:[87]

Social distance – for interactions among acquaintances:
Close phase - 4 to 7 feet
Far phase - 7 to 12 feet
Public distance – used for public speaking:
Close phase - 12 to 25 feet
Far phase - 25 feet of more

In addition, according to the *McGraw-Hill Encyclopedia of Chemistry*, we have the following definition:[86]

Molecular recognition – the ability of biological and chemical systems to distinguish between molecules and regulate behavior accordingly.

Subsequently, human social forces are regulated by a combination of force, distance, and recognition; according to which, each process is defined by virtue of attractive and repulsive quantum electrostatic interactions between molecules. In human terms, those at a sporting event with one team's colors on will be recognized as one type of species as contrasted with those wearing the opposite team's colors. This molecular recognition will mediate a subtle force.

In 1910, to review, in a lecture entitled 'pseudo association', given before the Royal Academy of Sciences in Amsterdam, van der Waals outlined a view in which molecules associate to form larger complexes, particularly in the liquid state, that the attraction of molecules decreases extremely quickly with distance, and that the attraction only has an appreciable value at distances close to the size of the molecule. Here, van der Waals is outlining the distinction between tight chemical bonds and weaker social intermolecular forces. He continues, these two types of forces, which can diminish quickly have two distinct consequences, namely they result in the formation of molecular complexes, such as cliques, but that they also lead to the creation of a surface pressure. To elaborate on this, van der Waals states that 'if we let the number of molecules that have combined into a complex be so large that it is possible to speak of a molecule at the center surrounded by a single layer containing almost as many other molecules as it is possible simultaneously, then for the surrounding molecules the attraction is directed towards the interior and acts to maintain the complex; and this part of its attraction is lost for the surface pressure.'

In human molecular terms, this statement defines the complex human molecular aggregate of, for example, the popular Super Bowl, the second-largest U.S. food consumption day, following Thanksgiving.[88] Here, the key players are at the center of the aggregate, the dynamic exchanges that occur between the players mediates the *exchange force* of the event, the spectators surround the central teams in 'layers' of hierarchical seating distributions, and the heighten, patrolled, energetic fenced in perimeter creates a type of surface pressure, with scalpers, bottle collectors, and ticket seekers, etc., on the direct outside and security guards, vendors, and concession stand people, etc., on the near-inside.

Nearing the concluding point of his 1910 Nobel Lecture on the development of the *equation of state* for gases and liquids, as discussed, van der Waals notes that it was of great importance for him to have been acquainted with Gibbs' 1876 treatises on the equilibrium of heterogeneous substances, which Gibbs had sent him shortly after their appearance. The central concept gained from Gibbs' treatises, according to van der Waals, was the principle that 'for a given amount of substance, equilibrium sets in if the free energy is minimum for the temperature and volume.' On this postulate, van der Waals introduced a parameter called the *degree of association*, which hypothetically exists between individual molecules, varying per relationship. Although he does not elaborate on this 'degree of association', he does point out that it is determined by means of Gibbs' equation, and that the factors related to this degree of association must be introduced into the equation of state. Müller, as we will show, correctly explained van der Waals' degree of association postulate via Gibbs' equation [4.10], namely through use of thermodynamic potentials.

The first quantum mechanical theory of dispersion forces, i.e. that of the basic interaction between noble gas atoms, was given by German-born American physicist Fritz London in 1930.[89] He used a quantum mechanical theory based on second-order perturbation theory.[90] The perturbation is the Coulomb interaction V between the electrons and nuclei of the two *monomers*, i.e. atoms or molecules, that constitute the *dimer*, i.e. a compound formed by the union of two radicals or two molecules. The second-order perturbation expression of the interaction energy contains a sum over states. The states appearing in this sum are simple products of the excited electronic states of the monomers. Thus, no intermolecular antisymmetrization of the electronic states is included and the Pauli exclusion principle is only partially satisfied.[91]

London developed the perturbation V in a Taylor series in $1/R$, where R is the distance between the nuclear centers of mass of the monomers.[92] This Taylor expansion is known as the multipole expansion of V because the terms in this series can be regarded as energies of two interacting multipoles, one on each monomer.[93] Substitution of the multipole-expanded form of V into the second-order energy yields an expression that resembles somewhat an expression describing the interaction between instantaneous multipoles. Additionally an approximation, named after

German astrophysicist Albrecht Unsöld, must be introduced in order to obtain a description of London dispersion in terms of dipole polarizabilities and ionization potentials. In this manner the following approximation is obtained for the dispersion interaction E_{AB}^{disp} between two atoms A and B:

$$E_{AB}^{disp} \approx -\frac{3\alpha^{A}\beta^{B}I_{A}I_{B}}{2\left(I_{A}+I_{B}\right)}R^{-6} \qquad [15.3]$$

where α^A and α^B are the dipole polarizabilities of the respective atoms, the quantities I_A and I_B are the first ionization potentials of the atoms, and R is the intermolecular distance.[82]

Here, we note that the London equation does not contain instantaneous dipoles, e.g. molecular dipoles, which are molecules that have dipole moments due to non-uniform distributions of positive and negative charges on the various atoms. The 'explanation' of the *dispersion force* as the interaction between two such dipoles was invented after London gave the proper quantum mechanical theory. The London theory has much similarity to the quantum mechanical theory of *light dispersion*, which is why London coined the phrase 'dispersion effect' for the interaction that we described here.[94]

In the years following the development of the conception of the intermolecular forces, i.e. Van der Waals forces, dispersion forces, and thermodynamic potentials, scientists soon began to apply these terminologies, in simple and loose analogy, to human interactions and social forces.

In 1995, for instance, author Elias Khalil, in his *American Journal of Economics and Sociology* article 'Nonlinear Thermodynamics and Social Science Modeling: Fad Cycles, Cultural Development, and Identification Slips', argued that, owing to the effects of entropy, individuals in social systems are similar to molecules and that 'there is a tendency for adjacent individuals to be pulled toward an equilibrium state', e.g. such as found in group memberships, societies, cities, etc.

In 1997, Swedish physical chemist Sture Nordhom, in his *Journal of Chemical Education* article 'In Defense of Thermodynamics: an Animate Analogy', states that 'thermodynamics explains what *drives* inanimate behavior, i.e. which processes will spontaneously occur and towards what equilibrium conditions they strive.' Thus, as he says, 'we might apply this theory also to economic behavior of humans.' He states that because of entropy in the combined law of thermodynamics that 'nature seeks to minimize the free energy of a subsystem' and that the corollary of this law in human life is that people 'seek to maximize their freedom'. Thus, as he says, 'we should understand the desire of some one to be rich as the desire to become free.'

Likewise, in the 2000 issue of the *Journal of Entropy*, engineer Josip Stephanic, physicists Hrvoje Stefancic and Mislav Zebec, and sociologist Kresimir Perackov, in their article 'Approach to a Quantitative Description of Social Systems Based on Thermodynamic Formalism', argue that social systems are defined by quantities

called *social potentials* and that these are quantified by *thermodynamic potentials*. They define a social system as a mode of organization of action elements relative to the persistence or ordering processes of change of the interactive patterns of a plurality of actors. These processes of social change, according to these authors, are described by systems that are divided into exact thermodynamic coordinates driven by thermodynamic forces. They state that 'combinations of these variables used for determining the present and predicting the future system states are called thermodynamic potentials, and to these belong internal energy U, Helmholtz energy F, enthalpy H, and Gibbs potential G, as well as the grand-canonical potential Ω.'

Similarly, in the 2001 paper 'Social Entropy' published by the *Nexial Institute*, engineering professor Alfredo Infante argues that *social entropy* is the quantity that measures the effects of the second law of thermodynamics in human social behavior. He argues that the 'state' of a human society as a system is described by the degree of dissatisfaction or satisfaction with the social, political, and economic rules. He states that in social systems the Gibbs free energy is the total energy in the system less the energy that is unavailable and that this difference represents the 'state' of the social system.

Other articles similar to these exist in the fields of thermoeconomics. Most of these articles, such as above, although very interesting reads, tend to generalize thermodynamic principles in ways that lack in rigor and clarity. The correct way to build a rigorous theory of social thermodynamics is to ask: (1) what forces act on a single human molecule; (2) how do these forces assimilate to mediate the bulk behaviors of collectives of human molecules; (3) how are these forces and social behaviors mapped, equation-wise, into measurable social gauges and thermodynamic potentials.

These conditions were met head-on by Venezuelan chemical engineer Erich Müller in 1998 *Journal of Chemical Education* article 'Human Societies: a Curious Application of Thermodynamics'. In this article, he first correctly defined humans to be analogous to molecules, then quantified inter human molecular love and hate in terms of basic thermodynamic pair bonds, and lastly quantified social forces as a type of van der Waals dispersion force.[80]

Müller reasoned that just as basic *statistical thermodynamics*, which is the study of the microscopic behaviors of thermodynamic systems using probability theory, predicts macroscopic behaviors of systems through knowledge of intermolecular interactions and appropriate averaging among the large number of molecules that constitute a system, that, in human social terms, if we can come to understand the collective behavior of the system we then comprehend the interactions on an individual basis.[95] Using this logic, together with the concept of 'potentials' from classical thermodynamics, he explains correctly how social interactions are functions of quantum electrostatics and thermodynamics.

Müller, who is currently is a reader (professor) in thermodynamics at the famed Imperial College London, is well versed in thermodynamics, particularly on the subject of molecular dynamics in fluid systems.[96] Between 1988 and 2006 he published over 43 articles in this field, from a 'Theory of Simulation of Associating Fluids' (1994) to 'Mesoscopic Simulation of Aggregation of Asphaltene and Resin Molecules in Crude Oils' (2006).[97] In 2002, he published *Basic Thermodynamics*, an introductory textbook.[98]

Beginning in 1990s, to enlighten his lectures and to get his students interested, Müller began to compare people to molecules. This later resulted in his 1998 article 'Human Societies: a Curious Application of Thermodynamics', where he compared human bonds to hydrogen bonds and social and political bonds to van der Waals dispersion forces.[79]

In his article, he begins his hypothesis that humans and molecules are the same and that social systems can be described by thermodynamics, by noting that the original founding fathers of thermodynamics, namely, 'Watt, Clausius, Carnot, Joule, and Gibbs' had no 'appreciable comprehension of the exact constitution of matter'. As such, the laws of classical thermodynamics are framed such that they can be applied to most systems. This happy occurrence, according to Müller, is the essential reason we can extrapolate the fundamental concepts of thermodynamics to other disciplines, such as geology, medicine, and sociology. In caution, however, Müller states that analogies must be made carefully and that, in reference to social forces, 'the fundamental electrostatics and quantum mechanics needed to fully explain the nature and form of intermolecular forces are beyond the scope of this discussion.' These 'beyond the scope' discussions, Müller is referring to here, is what was covered in chapters five though nine herein.

Nevertheless, he continues with excellent statements, such as 'the solidness of a society depends on the strength of the particular bonds among their members.' In addition, there is a 'loose analogy between the intermolecular forces that govern observable behavior in fluid systems and the social forces that drive human behavior.'[79] According to Müller, we understand pressure as a result of forces between molecules in a fluid; whereby, we can understand the collective behavior of the system if we can comprehend interactions on an individual level. In human molecular terms, these pressure correlations have been confirmed.[99]

Müller further elaborates on the fact that even the most insignificant molecule of the simplest compound interacts with its neighbors by means of specific forces. The underlying cause for the presence of these forces is the physical separation of positive and negative charges in the atom. He goes on to present the argument that both molecules and humans are governed by roughly similar electromagnetic potentials. Instead of speaking of forces, Müller states, 'thermodynamicists prefer to talk about potentials, whose variation with respect to distance represents the force;

potentials have the advantage of having units of energy, thus a discussion of some concepts is simplified.'

These potentials, Müller refers to, as discussed in chapters ten and eleven, are the enthalpic *H* and entropic *S* potentials, whose combined effects culminate in the measurement of the Gibbs free energy *G*, as defined in system evolution terms by the combined law of thermodynamics [4.27], previously known as the force of chemical affinity, defined originally by Newton in 1687.

Hence, as Müller explains, close proximity between molecules results in a state of 'repulsion', intermediate proximity results in a state of 'attraction', and at large distances, both humans and molecules do not interact directly and the potential is effectively zero. In relationship terms, we understand these balancings of attractions and repulsions in terms of Gottman stability ratios. Here, by analogy, we should be able to understand stabilities of any social system in terms of *Müller stability ratios*. This is an area in need of further researcher.

To give an example, Müller discusses the behavior of individuals at a party. As the guests enter the room, 'the first thing they do, after serving themselves a drink, is to mingle, wandering without direction.' Müller continues, 'the place themselves at judicious distances, not too close but not too far away, from others—a distance corresponding to the minimum of the *interhuman potential*. If we attempt to get too close to an individual, there will be an inherent repulsion.' To elaborate on this further, in his 1998 article, Müller draws a graph with 'force' as the vertical-axis, 'distance' between centers of mass on the horizontal-axis, and the potential interaction curve starting high in force at extreme close interactions, dipping to a minimum at intermediate distances, and petering out to a negligible value when interpersonal distances are great. Müller then states correctly that when the potential is negative, 'it represents a minimum corresponding to a distance at which the molecules find a balance between attractive and repulsive forces.' On his nice plot, we find a depiction of two people fighting at close range, a group of people watching a movie at intermediate range, and a singer person reading a book on the beach at interpersonal distances involving no appreciable interaction.

According to this logic, as Müller states, 'both at a human and a molecular level, even when the individual interactions may be somehow different and the fluctuations around the mean significant, the ensemble will have seemingly homogeneous properties if the number of individuals studied is extremely large.' Thus, 'if we start from the premise that molecules and humans are governed by roughly similar electrostatic potentials, thermodynamics may well describe the latter.' Moreover, 'the thermodynamic laws applicable to fluids may possibly describe some aspects of human society.'

Overall, one of Müller's central human molecular theories is that dominant social aggregations, such races, social classes, ghettos, Marxist societies, etc., result due to an electromagnetic force similar to that of *van der Waals force*, also known as

London dispersion forces. Dispersion forces are those that are weak in comparison to those found in covalent bonds. In human molecular terms, dispersion forces are weaker social forces that function to organize society. These forces are significant, but are weaker forces as compared to those found in the dihumanide bond.

Müller explains that in a multi-component fluid system, each molecule will have its own peculiar interaction. He states that even thought the qualitative shape of each molecule of the same species will be similar, that there will always be subtle and varying differences among members. If, for example, according to Müller, 'there are two types of molecules, say type *A* and type *B*, the potential minimum might be deeper between self-self *A-A* and *B-B* interactions than with unlike *A-B* interactions.' Müller further states that in a complex fluid, analogous to a complex, but fluid, human society, there might be symbiotic relationships: 'two molecules may bond for mutual benefits, such as exemplified by electron-transfer bonds, or there may be a strong repulsion due to dissimilar cross-interaction forces.' Similarly, Müller continues, 'in human society, our own individuality will draw us to some people while we strongly dislike others.'

To elaborate on this, to cite a very touchy example, Müller defines segregation in systems of molecules as *intermolecular racism*. Systems of oil molecules when placed into a system of water molecules, being so different from their neighbors, will tend to 'migrate to a boarder, avoiding unfavorable interactions.' If other nearby oil molecules are present, according to Müller, 'they will attempt to aggregate in the form of a molecular ghetto, thus achieving a more stable system.' This is obviously a very delicate subject, yet it is a subject in need of further analysis.

In 2005, to exemplify the need for analysis in this area, an anonymous bi-racial, bi-sexual, college student, of a Caucasian and African American descent, self-defined as 'living single, but in custody of a son', had at one point reviewed some early human thermodynamic articles on this subject, and asked pointedly 'why are white couples more stable than black couples?' He then asked 'how does thermodynamics explain this?' This delicate subject, being that it pits people against each other socially and sexually, is a difficult line of theoretical investigation.[100] Yet, instead of turning a cheek to this touchy topic, it is better to try to understand it from the scientific point of view. As history has shown, cultures come and go to no end.

In Müller's article, he elaborates that in heterogeneous molecular social systems, if minority molecules, having similar attraction preferences, are present in significant numbers, 'a phase separation will occur, creating a region where all interactions will be favorable' since all the members of the phase would be compatible in interaction behaviors. The border with the surrounding homogeneous phase, however, 'will not be free from high interfacial-tension.' The analogy with a homogeneous society, where small racial, cultural, and or religious groups appear, according to Müller, is obvious. Müller points out that world history is plagued with ample examples, such as the persecution of native inhabitants during the colonization of the Americas, the

separation of Pakistan and India, the Arab-Israeli conflict, and the disintegration of the Balkan states.[79]

In sum, according to Müller, all human social behavior, including love and hate, is governed by an 'interhuman potential' similar to that of insignificant molecules. In addition, these interhuman potentials are electromagnetic potentials that can be quantified in thermodynamic terms. Said another way, on the surface of the earth, it's not gravitational potentials that direct human behavior, but the electromagnetic force.

In 2006, Müller was interviewed by journalist Laura Gallagher, with *Reporter magazine,* for his popularity for his invigorating thermodynamic lectures in which he draws analogies between molecules and people. In the resulting article titled 'A Thermodynamic Personality', Müller states 'I make lectures a little more light-hearted to get everyone interested. Thermodynamics can be very close to everyday things but some of the textbooks can make it seem abstract. There is no need for it always to look that scary.' Likewise, according to Gallagher, Müller compares people with molecules to help his students understand interactions between molecules and visualise how they behave. 'Liquids come together because their molecules attract each other, just like human beings, who like to get close together at parties. However, molecules repel each other when they are too close in the same way that no-one wants to be approached by a close-talker.'[101]

These individual characteristics account for molecules' collective behavior. A group of the same type of molecules will stick together, just as a group of people might: 'Oil and water don't mix because they have a very different interaction—they prefer to be amongst molecules similar to each other instead,' he said. 'This is like humans and ghettos—in Copenhagen, for example, they tried to integrate the immigrant population with the otherwise rather homogeneous population by placing people in different parts of the city, but the immigrants eventually moved together and formed a ghetto,' he explained.[101]

'However, in a mayonnaise, you can have oil and water mixed together in an apparent single phase provided you have a molecule called a surfactant, which is fancied by both and can bring them together. In a similar way, only by including people who can talk to conflicting sides can different groups mix,' he continued. In these bold statements, Müller is generations ahead of himself.

Chemical potential

In human chemistry, chemical potential is the stored energy possessed by a human molecule or system of human molecules as a result of the relative positions of the components of that system in a reaction field.[102] A *reaction field* is the set of paths through which a single human molecule or system of human molecules may react in

the surrounding photonic field, in the biosphere. In short, chemical potential is the quantitative thermodynamic measure of human potential.

Chemical potential is a type of potential energy.[102] The term 'potential energy' was introduced in 1853 by Scottish engineer and physicist William Rankin.[103] Rankin was a founding contributor, with Sadi Carnot, Rudolf Clausius and William Thomson (Lord Kelvin), to the science of thermodynamics. The concept of potential energy was needed to account for apparent losses in kinetic energy or *vis viva*, as it was called.[104]

To elaborate, from [6.12], as derived by Isaac Newton in 1687, the gravitation potential energy for an object of mass m at a height h over the surface of the earth is defined as:

$$PE = mgh \qquad [15.4]$$

where g is the standard gravitational acceleration, which is approximately 9.8 m/s^2 at the earth's surface. The work done by the gravitational force as an object moves from an initial height h_i to a final height h_f is defined as:[105]

$$W_{gravity} = mgh_i - mgh_f \qquad [15.5]$$

Likewise, although ancient philosophers as far back as Thales of Miletus had inklings of the law of conservation of energy, in which still energy could be converted into movement energy, it was German polymath Gottfried Leibniz in the 1670s who attempted the first mathematical formulation. Leibniz noticed that in many mechanical systems, of several masses m_i each with velocity v_i, the quantity:

$$\sum_i m_i v_i^{\,2} \qquad [15.6]$$

was conserved and he called this quantity *vis viva* or 'living force' of the system.[106]

In the end of 18th century, the caloric theory was losing ground in competition with recent experiments involving heat, *vis viva*, and friction. In 1783, for instance, French chemist Antoine Lavoisier and French mathematician Pierre-Simon Laplace reviewed the two competing theories of *vis viva* and caloric theory, and found theoretical inconsistencies between the two. In 1798, Count Rumford's cannon boring experiments involving observations of heat generation and boiling water, lent weight to the view that mechanical motion could be converted into heat.[106] In 1807, English physicist Thomas Young showed that *vis viva* is actually *energy*, a term he coined, as we understand it in the modern sense.[104]

In 1829, French mathematical engineer Gustav Coriolis published a textbook called *Calcul de l'Effet des Machines* (Calculation of the Effect of Machines), which presented mechanics in a way that could be readily be applied by industry. In his

textbook, the correct mathematical expression for *vis viva* was shown to be that of *kinetic energy*, defined as:[107]

$$KE = \frac{1}{2}mv^2 \qquad [15.7]$$

Subsequently, during the turn of the 19th century, it was found that both conservative forces, such as gravity, and nonconservative forces, such as friction and air resistance, act simultaneously on objects. Moreover, according to the principle of conservation of mechanical energy, i.e. a subset of the first law of thermodynamics, it was discerned that the total mechanical energy E of an object remains constant as the object moves, provided that the net work done by the external non-conserved forces is zero, according to the following expression:[105]

$$E = KE + PE \qquad [15.8]$$

In other words, by example, according to [15.4] thru [15.8], if a 1 kg ball at the top of a 10-meter high frictionless hill is nudged, it will quickly transform its original store of potential energy:

$$PE = mgh = (1\text{kg})(9.8\ \text{m/s}^2)(10\text{m}) = 98\ \text{J}$$

into dynamic kinetic energy, i.e. energy of motion, as it rolls down the hill. Thus, knowing that the total energy will be conserved, i.e. $\Delta E=0$, during the process, we then find that:

$$\Delta E = \Delta KE + \Delta PE \rightarrow \Delta KE = -\Delta PE \rightarrow KE_f = 98\ \text{J}$$

Thus, via [15.7], we find that the final speed of the ball at the bottom of the hill will be:

$$KE = 98(J) = \frac{1}{2}mv^2 \rightarrow 98\left(\frac{kg \cdot m^2}{s^2}\right) = \frac{1}{2}(1kg)v^2 \rightarrow v = 14\ m/s$$

In other words, the stored energy possessed by the ball in the height of the earth's gravitational field was converted into the working energy of dynamic motion. In real situations, frictional effects will also play a significant role in the calculation.

Other examples of systems having potential energy include a stretched rubber band, and a pair of magnets held together so that the like poles are touching. Potential energy manifests itself in different ways. Electrically charged objects, for example, have potential energy as a result of their position in an electric field. An explosive substance has *chemical potential energy* that is transformed into heat, light, and kinetic energy when detonated.[102] Nuclei in atoms have potential energy

that can be transformed into other more useful forms of energy, such as is done in nuclear power plants.[102]

These principles apply in human life. In this situation, humans chemically react with each other over substrate, in some cases in explosive reactions of passion, and in the life course of these reactions, chemical potential energy is transformed into, primarily, the dynamic *working energy* of occupation, among other heat flow areas, such as personal frictions, social resistances, etc. Just as in the ball on the hill example, in which the operative force is gravitation, in the human substrate scenario, the operative force is the electromagnetic force, and the hills are electromagnetic potential energy hills, which can be visualized graphically.[108]

In other words, each human molecule, at any given point in his or her life, will be located in various sociological potential fields, in which various working reaction potentials can be realized depending upon which reaction path is followed. The overall trend in the system will be governed by the dynamic directional tendencies of combined law of thermodynamics, which dictates that each partitioned system will evolve in the direction that tends to minimize its total Gibbs free energy. Hence, the total set of individual reaction potentials will, on average, react such to minimize the total free energy of the system, converting stored chemical potential energy into working kinetic energy along the way.

Work, conversely, is needed to give a system potential energy. It takes effort to lift a ball off the ground, stretch a rubber band, or force two magnets together. In human terms, it takes effort to raise a young human molecule off the ground and into a respectable place in society. In fact, the amount of potential energy a system possesses is equal to the work done on the system.

In general, *potential energy* is the work done by a certain operative force, such as gravitational force, nuclear force, electromagnetic force, e.g. Coulomb force, etc., when the relative positions of objects are changed within a physical system.[109] In other words, it is the *work done* when an object is moved from one point to another. In human chemical terms, it is the work done when a human molecule dynamically reacts from one point in his or her life to another. Conceptually, potential energy can be thought of as the energy stored in an object as a result of the work done to bring it to that position from a reference point. When an object moves from one point to another, and there is a potential difference as a result of this, then work is performed. Potential energy is so named because this stored energy or work has the *potential* to change the state of other objects when released.

The work of the strong or weak nuclear force acting on the baryon charge is called *nuclear potential energy*. Chemical potential energy is often defined as the work of the Coulomb force during rearrangement of mutual positions of electrons and nuclei in atoms and molecules.[109]

Beyond these simple verbal descriptions, there are a number of ways to measure and quantify chemical potential energy. To begin with, in earth-bound reaction

systems, the *chemical potential* μ is the change in Gibbs free energy with respect to change in amount of the component, e.g. atom, molecule, or chemical species, with pressure, temperature, and amounts of other components being constant.[110] In addition, components in a system are said to be in equilibrium if their chemical potentials are equal.

In 1876, as discussed, Willard Gibbs introduced the word 'potential', which he defined as follows:[110]

> If to any homogeneous mass in a state of hydrostatic stress we suppose an infinitesimal quantity of any substance to be added, the mass remaining homogeneous and its entropy and volume remaining unchanged, the increase of the energy of the mass divided by the quantity of the substance added is the *potential* for that substance in the mass considered.

Gibbs noted, furthermore, that for the purposes of this definition, any chemical element or combination of elements, such as chemical species in a working body, in given proportions may be considered a substance, whether capable or not of existing by itself as a homogeneous body. Owing to the fortuitous, encompassing nature of this definition, namely, that 'substance' can be almost anything; we are graced with the exquisite methods to quantify potentials in human life.

In short, the chemical potential for an individual chemical species, such as one human molecule, is measured in terms of how it changes the internal energy U of the system to which it is introduced. The general rule with respect to migrations of species, into or out of the system, is that chemical species move from regions of high chemical potential to regions of low chemical potential.[46] In more detail, the first law of thermodynamics implies that there is a state function U, the internal energy, defined by its differential:[112]

$$dU = \sum(dQ + dW) = \sum X_i dx_i \qquad [15.9]$$

where X_i is a variable of *tension* and x_i a variable of *extensity*. An extensive quantity, or 'extensity', is a quantity proportional to the dimension of the system. The dimension may be: (1) a length, (2) a surface, or most often (3) a volume, an amount of electricity, an amount of substance, an entropy, the functions *U, H, F, G,* etc.[112] A 'tension' is partial derivative of the internal energy with respect to an extensity, other extensive quantities being kept constant.[112] Hence, with any extensity x_i it is always possible to associate a tension variable:

$$X_i = \frac{\partial U}{\partial x_i} \qquad [15.10]$$

which is called a conjugate variable.[113] Thus, chemical potential μ_i of the substance *i* is the tension associated with the extensity amount of substance n_i.

In thermodynamics, the central concept is that of energy, the ability to do work. As stipulated by the first law, the total energy of the system and its surroundings is conserved. It may be transferred into a body by heating, compression, or addition of matter, and extracted from a body either by cooling, expansion, or extraction of matter.[114] In mechanics, for comparison, energy transfer results from a force which causes displacement, the product of the two being the amount of energy transferred. In a similar way, thermodynamic systems can be thought of as transferring energy as the result of a 'generalized force' causing a generalized displacement, with the product of the two being the amount of energy transferred. These thermodynamic force-displacement pairs are known as conjugate variables. The most common conjugate thermodynamic variables are pressure-volume (mechanical parameters), temperature-entropy (thermal parameters), and chemical potential-particle number (material parameters).

Thus, the internal energy of a system is expressed in terms of pairs of *conjugate variables* such as pressure/volume (P-V) or temperature/entropy (T-V). In fact, all *thermodynamic potentials*, i.e. a function whose minimum gives the equilibrium state of a system subject to constraints, are expressed in terms of conjugate pairs.[115] For a mechanical system, a small increment of energy is the product of a force times a small displacement. A very similar situation exists in thermodynamics. An increment in the energy of a thermodynamic system can be expressed as the sum of the products of certain generalized *forces* which, when imbalanced cause certain generalized *displacements*, and the product of the two is the energy transferred as a result. These forces and their associated displacements are called conjugate variables. The thermodynamic force is always an *intensive variable* and the displacement is always an *extensive variable*, yielding an extensive energy transfer.[116] The intensive (force) variable is the derivative of the internal energy with respect to the extensive (displacement) variable, while all other extensive variables are held constant.[113]

Thus, when two systems A and B interact, the assembly (A + B) being isolated, the energy exchanged under the influence of a difference in tension is manifested by a transfer of extensity. The greater the difference in tension between A and B, the greater is the flux of the extensity crossing the boundary.[112] This definition has two consequences, one a tension is an intensive quantity which may be defined at each point in space, two tensions measured on both sides of the boundary separating two systems at equilibrium are equal.[112] To note, in applying these principles to human reaction systems, [15.9] and its derivatives can only be useful if we are able to express the chemical potential as a function of physical parameters of the which characterize the system.[117]

To cite one loosely applicable example, in electro-chemical reactions, such as in a *galvanic cell*, i.e. a system of two reactive metals connected via a salt bridge, the electrode potential is equal to the electromotive force of the cell.[118] If, in a galvanic cell, the overall reaction:

$$Ox_2 + Red_1 \rightarrow Ox_1 + Red_2 \qquad [15.11]$$

occurs, the electromotive force of the cell, from [11.10] and [11.11], $\Delta \mathcal{C} = \mathcal{C}_2 - \mathcal{C}_1$ is linked to the Gibbs free energy of the reaction by:

$$\Delta G = -nF\Delta \mathcal{C} = \Delta G^{\circ} + RT \ln \frac{[Ox_1] \cdot [\mathrm{Re}\, d_2]}{[Ox_2] \cdot [\mathrm{Re}\, d_2]} \qquad [15.12]$$

in which n is the number of reacting species, F is the faraday, and ΔG° is the Gibbs free energy for the reaction at standard state. In simple terms, in the system of the battery, the atoms of the two separated metal systems react with each other via the exchange of electrons, in the form of ions, through the connecting medium of the salt, and useful work is produced. This useful system work is measured by the change in the Gibbs free energy ΔG.

Hence, here we see a simple way of quantitatively correlating basic chemical potentials, to system electromagnetic driving forces, to productivity work output measures, as gauged in the form of Gibbs free energy measurements. Similar types of expressions can be developed for reactions such as [1.1] thru [1.24]. In other words, if instead of reaction [15.11], if we were to study a basic human chemical reaction, over substrate, of the form:

$$A + B \rightarrow C + D$$

in which *A, B, C*, and *D*, are either individual human molecules or systems of human molecules, linked by via any generic exchange-work energy flow mechanism, e.g. economic trade ties, similar to the salt medium of the voltaic cell, then human potentials and driving forces could be mathematically modeled.

Flow chemistry

In human chemistry, an advanced, still very theoretical, topic is that of *flow chemistry*, defined as flow of energy through human society as well as the flow of human particles themselves. These flows can by studied and quantified. This line of inquire can be approached from a number of perspectives. From a *fluid dynamics* perspective, humans can be modeled as particles flowing in certain orbital directions along substrate analogous to fluid particle flowing through pipes.[119] From an

electrical engineering perspective, human particles can be approximately modeled as charged particles flowing in conductive mediums, such as roadways, life paths, etc., encountering various resistances along the way, in a manner similar to electrons flowing through a conducting wire or light in a fiber optics cable.[120] In the *thermal sciences*, human psychological energies can be studied from the perspective of heat flows though society.[121] In *thermoeconomics*, we can study the flows of value energy associated with the economic production, distribution, and consumption of goods and services.[122] In *positive psychology*, flow is the individual feeling of complete and energized focus in an activity, with a high level of enjoyment and fulfillment.[123]

Beyond these basic examples, there will exist other types of human activity flow gauges, wherever one can discern a tool for tapping into a reading. Here, we will only lightly skim over a few basic ball-park analogy models that may give insight into more advanced models in the future. To begin with, in thermodynamics, for instance, chemical engineer Erich Müller in his 1998 article 'Human Societies—a Curious Application of Thermodynamics' states that 'the heterogeneity seen in all societies has clear resemblance to *fluid transport*, say through a pipe where molecules move at very relative velocities, even when the flow seems uniform.'[79] He continues 'we notice that molecules near the wall do not move while those at the center move with the highest speeds.' In society, Muller states, 'we have individuals who cling to the walls of the status quo while other, more progressive types, usually lead the way.'[79]

To elaborate further on this human energy flow, Müller states that the laws of thermodynamics tell us the manner in which energy is transferred in society. The first law, according to Muller, 'guarantees that we cannot create energy, a lesson all humans have experienced.' Similarly, the second law 'places restrictions on the flow of energy, giving it a preferred direction.' This is done by defining the ratio of heat flow, into or out of a system, to a system's temperature, namely that of entropy [3.10], which is a measure of the order and or disorder of a system. The only way to order 'either molecules or humans is through a transfer of energy between a system and its surroundings.'[79]

Curiously, Muller states that from an energetic point of view, 'the more complex a society becomes, the higher its rate of dissipation.' This is incorrect. As a system becomes more complex, its rate of dissipation decreases. This has been verified in the evolution of ecosystem, where it is found that the more complex deciduous trees are more energy efficient, dissipating less, than as compared to the less complex grass and shrubbery systems of which trees descended from.[124] Modern engines, likewise, dissipate much less energy than older steam engine models, from three-hundred years ago. American software designer Bill Gates, the current richest person in the world, is another example. His house, noted for its design and the technology, which exemplifies the efficiency of his lifestyle, one known for little waste and dissipation, was purchased in December 1988 for $2 million, and

construction occurred over a period of seven years with nominal completion in 1995. Electronics are used abundantly throughout the house. Visitors are surveyed upon entrance and are given a microchip that sends signals throughout the house to adjust temperature and other conditions according to preset user preferences.[125] This decreases the rate of energy dissipation, such as would be lost due to heat loss related to non-ideal temperature settings and fluctuations, as compared to less complex housing systems, e.g. older, less energy efficient houses.

In positive psychology, the psychodynamic conception of mental *flow* is defined as a conscious state of mind in harmoniously ordered.[126] In simple terms, it is a state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great costs, for the sake of doing it. In other words, in positive psychology, flow is a state of mental activity or operation in which the person is fully immersed in what he or she is doing, characterized by energized focus, full involvement, and success in the process of the activity.

The concept of flow in relation to mental contentment was developed by American psychologist Mihály Csíkszentmihályi who, beginning in the 1970s, interviewed and studied hundreds of successful people, such as musicians, athletes, artists, chess masters, and surgeons.[127] In his studies, he made people ware 'flow timers' in which at various randomized times during their workday a timer would go off and they document their flow state on paper. He then combined these data sets with Freud's dynamics views on social and psychological forces, psychic (mental) energies and entropies, and his thoughts on consciousness and intentions, to derive what he calls *flow theory*. Among his many books on this subject, the pinnacle publication was the 1990 book *Flow – the Psychology of Optimal Experience*, which introduced the world to the psychological concept of flow and optimal experience.[128]

In this book, he states that 'our perceptions about our lives are the outcome of many forces that shape our experience, each having an impact on whether we feel good or bad.' In addition, what we call intentions, he says, 'is the force that keeps information in consciousness ordered. Intentions arise in the consciousness whenever a person is aware of desiring something or wanting to accomplish something.' He states, by analogy, that intentions 'act as magnetic fields, moving attention toward some objects and away from others, keeping our mind focused on some stimuli in preference to others.' To exemplify, he says, for instance, 'the hunger drive that organized the content of the consciousness, forces us to focus attention on food.' Csíkszentmihályi argues that similar forces cause us to focus attention on more dominant tasks, such as a person's life work, passionate hobby, or adventure, as well as those activities prerequisite for mate acquisition, etc.

In sum, the concept of *flow* is a mental state of operation in which the person is fully immersed in what he or she is doing, characterized by a feeling of energized focus, full involvement, and success in the process of the activity. Developed, in the

mid 1970s, by Csikszentmihalyi, the concept has been widely referenced across a variety of fields. According to Jim Clifton CEO of the Gallup Organization, a firm that provides management consulting for 300-odd companies, for instance, 'people with *high flow* never miss a day? They never get sick. They never wreck their cars. Their lives just work better.' According to Clifton, flow is the ideal outcome of consulting work.[128]

Flow is so named because during Csikszentmihalyi's 1975 interviews several people described their 'flow' experiences using the metaphor of a current carrying them along. In this respect, the psychological concept of flow, as becoming absorbed in an activity, is thus a somewhat distant cousin to the saying 'to go with the flow', meaning to conform. In this case, however, when one senses that *to go with the flow* is the best route, it would be apparent that if one were to, instead, impose resistance there would result to be too great an amount of dissipated energy loss (entropic barriers), hence resulting in a less stable outcome. The converse may be true, however, in that, in certain situations, imposing resistance may result in change for the better in which a stable outcome results.

In physics, *electric current* is the flow of electrically-charged particles through a conducting circuit due to the presence of a potential difference.[129] In earth science, *current* is the flow of bodies of water molecules, or streams of air molecules, or of heat, moving in a preferred direction. Ocean currents are fast-flowing bodies of seawater moved by the wind or by variations in water density between two areas. Ocean currents are partly responsible for transferring heat from the equator to the poles and thereby evening out the global heat imbalance.[129]

In human chemistry, to modeled these protocols, we will set forth the following definition:

> **Human current** – the flow of charged reactive human molecules through a human circuit or reaction path due to the presence of chemical potential difference.

In electrical systems, current carries 'electrical energy' from a power supply, such as a battery or electrical cells, to the components of the circuit, where it is converted into other forms of energy, such as heat, light, or motion. In human systems, current carries human 'potential energy' from a power supply, i.e. the place, locus, or attractor wherein a person derives his or her motivational power or drive from, to the external components of a person's circuit or activity network, where it is converted into other forms of energy, such as work-output, production, motion, kinetic energy, etc. When current is in a state of 'high flow' we attribute this to the effect that there is little resistance in the conductor. When, conversely, a person is not able to lock into the 'flow state' we attribute this to the effect of there being great resistance, what we might call dissipative obstacles. The occurrence or development of 'heated

arguments' during the course of a person's workday are a prime example of a condition resulting in a resistance to flow. This is what is called the 'heating effect':

Heating effect – when current flows in a component possessing resistance, electrical energy is converted into heat energy.[129]

If the resistance of a component is R ohms and the current through it is I amperes, then the heat energy W, in joules, generated in a time t seconds is given by the formula:

$$W = I^2Rt \qquad [15.13]$$

In this manner, we have very ballpark and approximate method for calculating the amount of flow energy lost to dissipation, as via arguments, conflicts, obstacles, etc. Expression [15.13] should only be looked on as a base model such to use as an idea formulator for more accurate human chemistry models in the future.

In physics, *resistance* is that property of a conductor that resists the flow of electricity through it, associated with the conversion of electrical energy to heat. Materials that are good conductors of electricity have electrons held loosely in the outer shells of their atoms. Current can flow easily and these materials have low resistance. In poor conductors of electricity, the electrons in the outer shells of their atoms are more strongly attracted by the positive-charged nucleus. Such materials restrict the flow of electrons and have high resistance. Resistance R is related to the current I and potential difference or voltage V by the formula:

$$V = RI \qquad [15.14]$$

This statement, which states that current passing through a medium is proportional to the electrical potential difference between two points, is called Ohm's law. It was discovered by German physicist Georg Ohm in 1827. It is approximately true for many materials that are accordingly described as 'ohmic'. In human molecular terms, we see approximately that the flow of human current, as either directed energy, or as bodies in motion, is proportional to the chemical potential difference between the two points. The term 'gold rush', for instance, is defined as a rapid influx of fortune seekers to the site of newly discovered gold deposits.[130] Major gold rushes occurred in the United States, Australia, Canada, and South Africa in the 19th century. In human chemical terms, we would say, in these cases, that there existed a large 'potential' for gold discovery in these *hot regions* in which an increase of human current resulted proportional to the increase in the potential difference between the two regions, i.e. one in which there was little potential for gold discovery and one where there was great potential for gold discovery. On both the

finite electrical scale and on the larger human chemical scale, the electromagnetic force functions to create the potential difference.

Moreover, as a second example, in the beginning of the 21st century the mass introduction of computer application or information technology (IT) into the techno-hungry economy created or opened up a large potential need for IT specialists. As a result, a large 'potential' for people to make money in this newly created hot job market emerged. Hence, a large flow or 'IT rush' of people into this new untapped 'hot job' market resulted.

By definition, the current at any point of in a circuit is the amount of charge flowing per second; its unit, as mentioned, is the *ampere* or coulomb per second. A *coulomb* is the unit of electric charge. One coulomb is the amount of charge transferred by a current of one ampere in one second. The unit is named after French scientist Charles Coulomb.

Building on these definitions, regarding units of human current, or h-current, we will define an *h-coulomb* as the amount of charged energy transferred by an *h-current* of one *h-ampere* in one hour. In this manner, we have a means to measure the rate at which a charged human molecule invests energy into a desired activity or work expenditure per unit hour. Hence, *h-current*, from a second perspective, may be thought of as the amount of charged energy flowing per unit hour at any point in a human circuit. These terms are to be looked on as only testing models, and are not at all rigorous, but only something to think about or to build on.

Electrical current, i.e. a flow of negative charge, is measured in a similar way to water current, in terms of an amount per unit time; one ampere represents a flow of one coulomb per second, which is about 6.28×10^{18} electrons per second. The ampere is defined as the current that produces a magnetic force, specifically 2×10^{-7} newtons per meter, between two long, straight, parallel conductors placed 1 meter apart in a vacuum. It is named after the French scientist Andre Ampere.

In human chemical terms we may either measure the flow of motivationally charged human molecules passing through a flux region of space, such as door to a business, the gates to a football stadium, people on an expressway, etc., or we can measure the flow of charged motivation energy invested into an objective or work expenditure.

Current comes in two varieties: direct current or alternating current. *Direct current* is electric current or energetic current where the electrons, charged particles, or charged human molecules flow in one direction. Migration patterns, over evolutionary time periods, towards newly tapped resources niches may be thought of as direct current; or a one-way street may be though of a s direct current. The electricity produced in a battery is direct current. Electromagnets and electric trains, for example, use direct current.

Alternating current is electric current or energetic current that flows for an interval of time in one direction and then in the opposite direction; that is, a current

that flows in alternately reversed directions through or around a circuit. Alternating flow of human molecules into a city in the morning and out of a city in the evening, over the course of a typically workday, may be thought of as alternating current. Electric energy or human motivational energy is usually generated as alternating current in a power station, and may be used for power and lighting. Railways, factories, and domestic appliances, for example, use alternating current.

Again, any of various impediments to the action of flow or transmittal of current is what is called resistance, and results in the dissipation of energy a natural part of the second law of thermodynamics. This entire section on 'flow chemistry' is only a very rudimentary model, and is included here only as something to think about.

Le Chatelier's principle

In chemistry, *Le Châtelier's principle*, also known as 'Le Chatelier's laws' or the *Le Chatelier-Braun principle*, states that given a chemical system at equilibrium, every modification of a constraint results in making the system evolve in such a way as to neutralize the disturbance and restore equilibrium.[131] They express, in a simple non-mathematical language, the laws of equilibrium displacement. Said another way, if a chemical system at equilibrium experiences a change in concentration, temperature, volume, or total pressure; the equilibrium will shift in order to partially counter-act the imposed change.[132] It can be used to predict the effect of a change in conditions on a chemical equilibrium.

These fundamental laws were expressed in 1880s by French chemist Henri Le Chatelier, translator in 1899 of the works of Willard Gibbs and inventor of thermal analysis.[131] These equilibrium principles were also independently discovered by German physicist Karl Braun. Le Chatelier, the dominate one, however is known for his work on the principle of chemical equilibrium, otherwise known as Le Chatelier's principle, and on the variation of the solubility of salts in an ideal solution. Le Chatelier published approximately thirty papers on these subjects between 1884 and 1914. His results on chemical equilibrium were presented in 1885 at the Académie des sciences in Paris.[133]

In simple terms, an equilibrium is expressed by an equality between two terms. If we have an equality, we have and equilibrium. If an external intervention results in modifying one of the two terms, there is no longer equality, hence there is no longer equilibrium. To compensate, the system will evolve towards a new *equilibrium state*, i.e. it will react in the direction that restores the equality between the two terms.[131] This is the essence of Le Chatelier's law.

In application, we have many versions of this law. In terms of pressure, an increase in pressure displaces the equilibrium in the direction that tends to reduce the volume of the system. With dilution, an addition of solvent displaces the equilibrium in the direction that tends to increase the dissociation of the dissolved species. In

regards to temperature, an increase in temperature displaces the equilibrium in the endothermic direction, i.e. the direction that absorbs heat. In chemical potential terms, an increase in the chemical potential of only one constituent displaces the equilibrium in the direction that consumes it.[131]

In human system terms, Le Chatelier's law applies absolutely. If in a school system, per chance, an influx of one new student into a settled classroom occurs, it will temporarily displace the evolving equilibrium of the class. The system will react in the direction that will consume the new potential thus establishing a new equilibrium. In almost all human reaction systems, one can find Le Chatelier's laws at work, owing to the fact that that they are based on the combined law of thermodynamics, in particular the great works of Gibbs.

To cite one example of the use of Le Chatelier's principle in modeling shifts in human systems to external perturbations, in the 1940s American economist Paul Samuelson, an indirect student of Willard Gibbs, via his mentor Edwin Wilson (the last student of Gibbs), used Le Chatelier's principle to understand equilibrium shifts in economic systems. This application can be found in his 1947 book *Foundations of Economic Analysis*. The front motto of the book is that of the great Willard Gibbs: 'Mathematics is a Language.' The book attempts to show how economic purposes and actions can be parsimoniously and fruitfully met in the language of mathematics.[134] It focus on concepts such as equilibrium systems, such as for a market or economy, stability of equilibrium systems, dynamics, i.e. disturbances in equilibrium, and comparative statics, among other topics.[135]

In his 1970 Nobel Lecture 'Maximum Principles in Analytical Economics', he states 'as a last illustration of the black magic by which a maximum formulation permits one to make clear-cut inferences about a complicated system involving a large number of variables, let me recall the work I have done in formulating clearly and generalizing what is known in physics as Le Chatelier's Principle. This Principle was enunciated almost one hundred years ago by a French physicist interested in Gibbs-like thermodynamics.' The Le Chatelier Principle, according to Samuelson, states that: 'if you put an external constraint on an equilibrium system, the equilibrium shifts to "absorb" or "resist" or "adjust to" or "minimize" the change'. In this reaction equilibrium principle, that he learned during Wilson's lectures on thermodynamics, Samuelson states 'I was struck by his statement that the fact that an increase in pressure is accompanied by a decrease in volume is not so much a theorem about a thermodynamic equilibrium system as it is a mathematical theorem about surfaces that are concave from below or about negative definite quadratic forms.'

Armed with this clue, his desire was to make sense what Adam Smith's 'invisible hand' is supposed to be maximizing in relation to the physics of the Le Chatelier's Principle. His results are what he calls the Le Chatelier-Samuelson Principle: 'the heavy curve of longer-run adjustment, with other price constant (and

other quantity of course thereby itself adjusting *mutatis mutandis* to restore the maximum profit equilibrium), must be less steep or more elastic than the light curve depicting the demand reaction when the other input is held constant.' To throw a grain of theoretical caution into the wind, during his lecture, however, he also humorously states:

> There is really nothing more pathetic than to have an economist or a retired engineer try to force analogies between the concepts of physics and the concepts of economics. How many dreary papers have I had to referee in which the author is looking for something that corresponds to *entropy* or to one or another form of *energy*.

In Samuelson's formulation, a generalized Le Chatelier principle is used for a maximum condition of stable economic equilibrium, i.e. where all unknowns of the function are independently variable, auxiliary constraints, *just-binding* in leaving initial equilibrium unchanged, reduce the response to a parameter change. Thus, factor-demand and commodity-supply elasticities are hypothesized to be lower in the short run than in the long run because of the fixed-cost constraint in the short run.[136] In sum, according to Samuelson, not only in the theory of production but also in the general theory of constrained rationing does the Le Chatelier Principle have various economic applications.

In the next chapter, we will round off our discussion of human chemistry by giving a gist overview of human thermodynamics. As this book is intended to be a basic textbook on the subject of human chemistry, it is intuitive to see where the typical thermodynamic chapters are found in other standard chemistry textbooks. In this direction, in we have:

Author	Book	Year	Thermodynamics
Linus Pauling	*General Chemistry*, 3rd Ed.	1970	Ch. 10
Darrell Ebbing	*General Chemistry,* 3rd Ed.	1990	Ch. 18
Raymond Chang	*Chemistry,* 6th Ed.	1998	Ch. 18
Theodore Brown	*Chemistry*, 9th Ed.	2003	Ch. 19

In human chemistry, saving the best for last, our thermodynamics overview is in chapter 16, the following chapter.

16 – Human Thermodynamics:

"The laws of thermodynamics, as empirically determined, express the approximate and probable behavior of systems of a great number of particles, or, more precisely, they express the laws of mechanics for such systems as they appear to beings who have not the fineness of perception to enable them to appreciate quantities of the order of magnitude of those which relate to single particles, and who cannot repeat their experiments often enough to obtain any but the most probable results."

Willard Gibbs, *American Theoretical physicist and chemist*[1]

The most advanced subject of human chemistry is *human thermodynamics*, the chemical thermodynamic study of human molecular reaction life.[2] Chemical thermodynamics outranks all other branches of science in shear conceptual rigor, mathematical fortitude, and historical foundation.[3] German-born physicist Albert Einstein, discoverer of the equivalency of mass and energy, $E=mc^2$, once famous stated that '*classical thermodynamics* is the only physical theory of universal content which, within the framework of the applicability of its basic concepts, will never be overthrown.'[4]

Human thermodynamics, said another way, is the study of matter and energy transformations in human life processes.[5] Specifically, it is the combined sciences of particle physics, physical chemistry, evolutionary psychology, and thermodynamics; technically defined as the study of the interactions of heat, work, enthalpy, entropy, and free energy changes, in relation to *spontaneity* in human life processes.[6]

A pre-requisite to a residual understanding of basic human thermodynamics, not necessarily in terms of elementary principles, but rather in terms of an intuitive idea of the visual conception of the state equations and the physics parameters used in the application and modeling of daily human life, in its most basic, i.e. work, play, love, hate, etc., is to have a *Buffett-number* level competency.[7] The Buffet-number is 100.

In 1947, two-months shy of his seventeenth birthday, American business mogul Warren Buffett had read at least one hundred books on business. Shortly thereafter, he entered the Wharton School of Finance, wherein upon arrival he reported that 'he knew more than the professors'.[8] On a return trip home, Warren was warned not to neglect his studies. To this he replied insouciantly, 'all I need to do is open the book the night before and drink a big bottle of Pepsi-Cola and I'll make 100.'

The *Buffett-number* is the gauge of basic intellectual competence on any given subject. That is, for one to be fluent in their line of work or topic of interest, one needs to read one-hundred books on that subject. To be relatively knowledgeable on any given subject, one needs read fifty books, so to reach the *½ Buffett-number*. In human thermodynamics, then, to have a residual, basic, or intuitive understanding of the thermodynamics of human life, one needs to read, at a minimum, one hundred books and textbooks on thermodynamics, with focus on those in the specific area of chemical thermodynamics.[3] The seven books that best qualify, i.e. comprise, the foundation of human thermodynamics are:

"Human Thermodynamic" Fundamental Books	Authors	Pages
Reflections on the Motive Power of Fire (1824)	Sadi Carnot	66
The Mechanical Theory of Heat (1865)	Rudolf Clausius	365
On the Equilibrium of Heterogeneous Substances (1876)	Willard Gibbs	300
Thermodynamics and the Free Energy of Chemical Substances (1923)	Lewis & Randall	653
Modern Thermodynamics by the Methods of Willard Gibbs (1933)	Guggenheim	202
The Evolution of Desire – Strategies of Human Mating (1994)	David Buss	262
Thermodynamic Theory of the Evolution of Living Beings (1997)	Georgi Gladyshev	142

These seven fundamental books are the foundation of human thermodynamics. Any competent *human thermodynamicist* who builds on this set of core books will always theorize in the correct direction.

A central objective in human thermodynamics is to quantitatively predict who will react with whom, especially socially, work, friendship, date, and mate-wise, as determined through, before and after, chemical free energy calculations.[9] These are basic reaction calculations in modern-day physics, chemistry, and thermodynamics, with small molecular species, and should be the case with reaction combinations of human molecular species.[10] It will yet be some centuries, however, before this goal is realized in true fashion.

The immediate goal of human thermodynamics is to bring a unity and contiguity to the various human life sciences, namely those of biology, sociology, psychology, business, economics, politics, etc., and in particular evolutionary mate-date reaction selection science.[11] In short, the exacting objective of human thermodynamics is to quantify *social interactions*, i.e. dynamic, changing sequences of 'social actions' between individuals (or groups) who modify their actions and reactions according to the actions by their interaction partner(s), in terms of physical parameters, e.g. work, free energy, enthalpy, entropy, and generalized forces, etc., at both the *micro*-social (individual) and *macro*-social (community) level.[12]

Historically, a number of scientists who were instrumental in the development of human thermodynamics as a modern day science, too many to list at this point.[13] In short, however, in 1782 Scottish engineer James Watt, student of Scottish pre-

thermodynamics chemist Joseph Black, was working with ponies lifting coal at a coalmine, and he wanted to define the power available from one of these animals.[14] He found that, on average, a mine pony could do 22,000 foot-pounds (lift a bucket of coal weighing 22,000 lbs a distance of 1-foot) of work in a minute. He then increased that number by 50 percent and fixed the measurement of horsepower at 33,000-foot-pounds of work in one minute. Under this system, one horsepower is defined as *1 hp = 33,000 ft·pound-force·min*$^{-1}$ *= 745.7 Watts*. The term *horsepower*, i.e. the power that a horse exerts in pulling (doing work), based on Watt's experiment, was coined in 1806.[15] Human power or *man-power*, a term from 1862, defined as power available from or supplied by the physical effort of human beings or the power that a human develops in doing work, can likewise be defined by experiments such as these.[16]

A recent application of this is Forbes annual list of the world's most powerful men and women, which thus quantifies Watt's power in more indirect ways. To note, in making this comparison, there are many hardened scientists who will argue that Watt's *pony power* and Forbes *world power* are two completely different quantifications, the former being an exact physics definition, the latter being only metaphor. This is where the difficulty lies. How does one measure, for instance, Oprah Winfrey's power, #14 in 2006, in a manner equivalent to the lifting of buckets of water per unit time? Moreover, what does Oprah's power have to do with daily household reactions and the work derived therefrom? These types of deep questions are at the heart of human thermodynamics.

In 1824, based experiments by Watts and others, French physicist Sadi Carnot founded thermodynamics with his 66-page treatise 'On the Motive Power of Fire', in which he used dynamical equations to quantify the flow of heat and the production of work in engines.[17] His central contributions are, firstly, that he defined *work* as the energetic measure of a 'weight lifted through a height', as modeled on the fact that the original use of engines was to replace teams of horses (horse-power), who were used to lift buckets of coal and water *through a vertical height* out of flooded salt and iron mines through-out Europe:[18]

$$W = mgh \qquad [16.1]$$

Second, Carnot laid out the framework of the second law of thermodynamics, done previously in terms of caloric by French chemist Antoine Lavoisier, by defining heat flow between bodies in terms of the work produced by engine cycles.[19]

In 1834, French mining engineer Émile Clapeyron used the recently invented *indicator diagrams*, developed by Watt, which are engine cycle pressure-volume graphs, to put Carnot's theories on a functional calculus-based footing.[20] The total work done by the steam, in Carnot's engine cycle, could now be calculated through integration of the area of the work-cycle, as shown between the volume axis and the

traced line on the indicator diagram. In human thermodynamics, to note, what is in great need is the development of a 'human indicator diagram'.

In 1843, where Carnot has previously showed that heat could produce work, in the form of the effort exerted in *raising* a weight through a height, English physicist James Joule, in his paper 'The Mechanical Equivalent of Heat', showed that work released, in the form of a weight *falling* through a gravitational height, could produce heat, as measured via a temperature increase in a tub of water due, to the frictional agitation of a paddle wheel.[21] This experiment, among others performed by Joule, cemented the universal acceptance of the first law of thermodynamics.[22] Joule's statement of the first law is 'the mechanical power exerted in turning a magneto-electric machine is converted into the heat evolved by the passage of the currents of induction through its coils; and, on the other hand, that the motive power of the electro-magnetic engine is obtained at the expense of the heat due to the chemical reactions of the battery by which it is worked.'[21]

Others who stated complementary versions of the first law of thermodynamics include the German physician and physicist's Robert Mayer (1841) '*energy can be neither created nor destroyed*' and Hermann von Helmholtz (1847) 'vital heat is the product of mechanical forces within the organism; all heat is related to ordinary forces; *force itself can never be destroyed*.'[23] Most jointly cite Mayer (1841), Joule (1842), and Helmholtz (1847) as being the primary originators of the first law of thermodynamics.[24] In modern terms, force and energy are understood to be one and the same, being comprised of elementary particles called *bosons*, namely the Gauge bosons, i.e. gluon, W and Z bosons, and the photon, and other hypotheticals such as the Higgs boson and graviton .[25]

In 1865, building particularly on the theories of Carnot, Clapeyron, and Joule, German physicist Rudolf Clausius, published his 365-page book *Mechanical Theory of Heat*, in which, first and foremost, he defined a new quantity, namely *entropy*:

$$S = \frac{Q}{T} \qquad [3.10]$$

Here Q is the quantity of heat which must be imparted to a body during its passage, in a given manner, from one condition to another, and heat withdrawn from the body being counted as an imparted negative quantity of heat, and T is the absolute temperate of the body.[26] The importance of this decisive definition [3.10] cannot be over-estimated. From the time of Hippocrates (460BC) the *father of medicine*, who stated 'heat (Q) a quantity which functions to animate, derives from an internal fire located in the left ventricle', to the time of Lavoisier (1787) the *father of chemistry*, who enunciated 'that every body, whether solid or fluid, is augmented in all its dimensions by any increase of its sensible heat (Q), was long ago fully established as a physical axiom, or universal proposition, by the celebrated Boerhaave', we have

studied quantities of *heat* '**Q**'.[26] From the time of Clausius (1854) to the present and likely for many millennia to come, we will study quantities of *entropy* '**Q/T**'.[27]

Second, and equally important, Clausius presented both the first and the second laws of thermodynamics in a language of calculus and clarified their operation in terms of descriptions of atomic and molecular organizations.[28] Specifically, in 1862 Clausius defined *disgregation* as the magnitude of the degree in which the molecules of a body are separated from each other.[29] This term was modeled on certain passages (namely 'mode of aggregation') in Carnot's 1824 paper that characterized the transformations of *working substances*, i.e. atomic and molecular species of a *thermodynamic system*, of an engine cycle, which was a precursor to the concept of entropy, a term later coined by Clausius in 1865.[30]

In 1862, to clarify, Clausius asserted that any *thermodynamic process*, i.e. any process driven by heat, always 'admits to being reduced to the alteration in some way or another of the *arrangement* of the constituent parts of the *working body*' and that *internal work* associated with these alterations is quantified energetically by a measure of the 'transformation content' (entropy) change, according to the following differential expression:[29]

$$\int \frac{dQ}{T} \geq 0 \qquad [16.2]$$

These system arrangement and transformation conceptions later became precursors to the ordering and disordering atomic molecular system views of Austrian physicist Ludwig Boltzmann as well as those of German physician and physicist Hermann von Helmholtz.[31] In 1882, for instance, Helmholtz used the German word 'Unordnung' (disorder) to describe entropy.[32]

In 1876, building on the platform of Clausius, American mathematical engineer Willard Gibbs scripted his monumental, densely woven, 300-page treatise *On the Equilibrium of Heterogeneous Substances*, which described thermodynamic reaction tendencies in a visual, three-dimensional graphical language of Lagrangian calculus and phase changes.[33] American historian Bill Bryson describes Gibbs' *Equilibrium* paper as "the *Principia* of thermodynamics".[34] Gibbs, above all, is the key figure in human thermodynamics.

The central question in any chemical reaction process, from the point of view of the laws of thermodynamics, according to Gibbs, is, given any dynamical, material, potentially reactive system: 'what is the criterion for equilibrium?' If a system is at a state away from equilibrium, it will naturally and invariably evolve towards the point of equilibrium, at which time, changes in the system will cease. By determining the *criterion for equilibrium* for any system, human systems included, its equilibrium point can be determined, thus allowing one to predict the spontaneity of the system.

One example of the ubiquitous applicability of Gibbs' equilibrium criterion for use in the mathematical modeling of human life, as discussed, is the work of

American mathematical economist Paul Samuelson, winner of the 1970 Nobel Prize in economics.[35] Samuelson was protegé of the polymath Edwin Wilson, who had himself been the sole protegé of Gibbs.[36] According to American thermoeconomist Panagis Liossatos, 'the methods of classical thermodynamics, as perfected by the great American physicist J. Willard Gibbs, inspired Samuelson's path-breaking 1947 book [*Foundations of Economic Analysis*] on constrained optimization and comparative statics in economic analysis.'[37]

In 1941, Samuelson, then a burgeoning graduate economics student at Harvard University, submitted his dissertation titled 'The Observational Significance of Economic Theory' to the David A. Wells Prize Committee of Harvard.[38] In 1947, he expanded his dissertation into the book *Foundations of Economic Analysis*, his magnum opus, which includes topics such as equilibrium systems, e.g. market or economy, maximization behavior, e.g. profits by a firm and utility by a consumer, in the calculus of sales-tax increase on equilibrium for a firm, and consumer behavior, among others.[38] The book shows how basic economic processes and data can fruitfully be met in the language of mathematical thermodynamics.

In 1947, for his thermoeconomic work, Samuelson was awarded the John Bates Clark Medal, a biennial medal awarded by the American Economic Association to any American economist under the age of forty who is 'adjudged to have made a significant contribution to economic thought and knowledge'.[39] His follow-up 1948 book *Economics* became a classic textbook that gave birth to modern economics, selling millions copies in more than 40 languages.[40] In 1970, Samuelson was sole recipient of the Nobel Prize in Economics, the second year of the Prize.[41] In the 1983 *expanded edition* of his 'Foundations', Samuelson himself gives a fascinating account of the influence of Gibbs in modern economics.[37]

The comprehension of the laws which govern any material system, according to Gibbs, is greatly facilitated by considering the energy E and entropy S of the system in the various states of which it is capable.[42] As the difference of the values of the energy for any two states represents the combined amount of work and heat received or yielded by the system when it is brought from one state to the other, and the difference of entropy is the limit of all possible values of the integral:

$$\int \frac{dQ}{T} \qquad [16.3]$$

in which dQ denotes the element of heat received from external sources, and T is the temperature of the part of the system receiving it, the varying values of energy and entropy characterize *in all that is essential* the effect producible by the system in passing from one state to another.[42]

It is not only in respect to the external relations of a system that its energy and entropy are of predominant importance. As in the case of simple mechanical systems, such as are discussed in theoretical mechanics, which are capable of only

one kind of action upon external systems, namely the performance of mechanical work, the function which expresses the capability of the system of this kind of action also plays the leading part in the *theory of equilibrium*, the condition of equilibrium being that the variation of this function shall vanish, so in a thermodynamic system, such as all material systems are, which is capable of two different kinds of action upon external systems, the two functions which express the twofold capabilities of the system afford an almost equally simple *criterion for equilibrium*.[42] This is the platform upon which human thermodynamics is built. The entire edifice of human life can be quantified by these statements of Clausius and Gibbs.

In 1882, German physician and physicist Hermann von Helmholtz showed, in a style of rigorous mathematics equivalent to Gibbs, in his article *Die Thermodynamik chemischer Vorgange*, that the two fundamental functions of the thermodynamics of Clausius, namely E, the energy of the system, and S, its entropy, could be replaced by a new function called the 'free energy', which in isothermal systems is:[43]

$$F = E - TS \qquad [16.4]$$

Here, F represents the total system energy E less the bound energy TS of the system and is that which can be *freely* converted into other forms of work. Technically, the Helmholtz free energy change ΔF of a system during a real transformation equals the work exchanged with the surroundings external to the system during every *reversible* transformation between the same initial state to the same final state.[44] In accordance with the second law, if the transformation is reversible, the work exchanged with the surroundings of the system is a minimum. Explicitly, if $\Delta F > 0$, ΔF represents the minimum work that must be supplied to the system to carry out the transformation; if $\Delta F < 0$, $|\Delta F|$ represents the maximum work that can be extracted from the system during the transformation.[44] In the absence of any *external field*, [16.4] may be defined as:

$$F = U - TS \qquad [11.8]$$

In isobaric, isothermal systems, the Gibbs free energy is defined as:[45]

$$G = H - TS \qquad [2.1]$$

The Gibbs free energy may also be defined from the Helmholtz free energy:

$$G = F + PV \qquad [16.5]$$

Here H is the enthalpy of the thermodynamic system and P and V the pressure and volume, respectively. Similarly, if $\Delta G > 0$, ΔG represents the minimum work that

must be supplied to the system to carry out the transformation; if $\Delta G < 0$, $|\Delta G|$ represents the maximum work that can be extracted from the system during the transformation.[45] In short, when a *system* evolves from a well-defined initial state to a well-defined final state, the measure of the Gibbs free energy change ΔG equals the work exchanged by the system with its surroundings, less the work of the pressure forces, during a reversible transformation of the system from the same initial state to the same final state.[45] In human relationship terms, the criterion $\Delta G < 0$ means that a relationship will work and that $|\Delta G|$ represents the maximum work that can be extracted from the working relationship, approximately. Conversely, if $\Delta G > 0$, ΔG represents the minimum work, i.e. work put into a relationship, that must be supplied to the system, e.g. to a marriage, to carry out the transformation.

In comparing the two free energies, the Gibbs free energy is the most commonly used measure of thermodynamic potential, especially in the field of chemistry. The isobaric restriction on this quantity, however, is sometimes inconvenient. Thus, in explosives research, for example, the Helmholtz free energy is used since explosive reactions by their nature induce pressure changes.

Helmholtz, according to historians, likely derived most of his free energy ideas from those of Gibbs.[46] To elaborate, in 1863, Gibbs was awarded the first Ph.D. degree in engineering in the USA from the Sheffield Scientific School at Yale. He then tutored at Yale, two years in Latin and one year in what was then called natural philosophy, now comparable to the natural sciences, particularly physics. In 1866, he went to Europe to study, spending a year each at Paris, Berlin, and Heidelberg. While at Heidelberg, Gibbs studied for two semesters, 1868-69, at Europe's third oldest educational institute the *Ruprecht Karls University,* founded in 1386, more commonly known as the University of Heidelberg. At the time, German academics were the leading authorities in chemistry, thermodynamics, and theoretical natural science in general. We know from his school prospectus that luminaries such as Gustav Kirchhoff, Otto Hesse, Moritz Cantor, Friedrich Rummer, Paul du Bois-Reymond, and others, were lecturing in courses in mathematics and mathematical physics; that Robert Bunsen gave a course in experimental chemistry; and that Helmholtz lectured for the first semester in an orientation course on the general results of the natural sciences, which was open to all students.

It is not known, however, if Gibbs attended Helmholtz's lectures. Yet it can be inferred that Gibbs influenced Helmholtz. According to the pre-1950s testimony of Professor Michael Pupin, for instance, Helmholtz 'must have become acquainted with Gibbs' work in the mid-eighties'.[47] Likewise, according to a March 1889 letter addressed to Gibbs by German physicist Heinrich Hertz, to whom Gibbs had sent his papers, 'many of the things which I thought had been first done by Helmholtz I found in your paper.'[48] Similarly, in a 1893 visit to the United States, Helmholtz expressed his regret at missing an opportunity for a talk with Gibbs.[49] In short, although it can not be confirmed that Helmholtz had a read Gibbs' paper prior to

1882, we do know that Gibbs published the last part of his *Equilibrium* paper in 1878, that he had a mailing list of over two hundred of the most notable scientists of his time, including Poincaré, Hilbert, Boltzmann, and Mach, etc., and that he sent copies of his *Equilibrium* paper to scientists in Germany.[46] Hence, owing to the similarity of Helmholtz's derivations to those of Gibbs, it is likely that Helmholtz knew of Gibbs' theories prior to 1882. They both, however, were original in their own right, i.e. in particular Helmholtz was electro-chemical oriented, whereas Gibbs was phase-change oriented.

In any event, these fundamental expressions, [16.4], [11.8], [2.1], [16.5], which Gibbs had derived originally beginning in 1873, but with out the needed verbal clarification added by Helmholtz, essentially overthrew the older science of *thermochemistry* and replaced it with the newer, more accurate, science of chemical thermodynamics, to which both Gibbs and Helmholtz are considered as founders.[42] In the older classical thermochemistry, by contrast, as founded by Danish chemist Julius Thomsen and French chemist Marcellin Berthelot, the heat evolved in a chemical reaction was the true measure of affinity A, i.e. the long-sought 'force' of chemical reactions.[50] The theory rested on the *Thomsen-Berthelot principle*, which stated that all chemical reaction changes are accompanied by heat production and that the actual process which occurred was the one in which the most heat was produced.[51]

In 1882, however, Helmholtz proved, through derivation, that the affinity A was not given by the heat evolved in a chemical reaction but rather by the maximum work produced, as measured by a decrease in the free energy in the system, when the reaction was carried out *reversibly*.[52] In short, whereas the older views focused on energy measures in terms of heat flows, Helmholtz conceptually divided the portion of the total energy E of a thermodynamic system, available for conversion to other forms, as 'free energy', G or F, and the residual 'bound energy', TS. In his own words, 'given the unlimited validity of Clausius' law, it would then be the value of the *free energy*, not that of the *total energy* resulting from heat production, which determines in which sense the chemical affinities can be active.' In other words, free energy, F or G, is that part or the total or internal energy U that can be transformed completely into heat, electrical energy, mechanical energy, etc.

In modern-day terms, using the thermodynamic methods of Clausius, Gibbs, and Helmholtz, *internally*, i.e. for all metabolic processes internal to the human body, is considered a matter of fact.[53] In 1993, for instance, American biochemist Albert Lehninger, widely regarded as a pioneer in the field of *bioenergetics*, in his textbook *Principles of Biochemistry*, defines Gibbs free energy 'as the amount of energy capable of doing work during a reaction at constant temperature and pressure'.[54] In human chemistry, the definition is the same. Gibbs free energy it is the amount of *system energy* capable of doing work during a *human chemical reaction* at constant temperature and pressure.

Scripting this standard definition *externally*, i.e. for all thermodynamic reaction processes occurring between humans, and the work produced therefrom, due to the drive of sexual or interpersonal relationships, particularly romantic relationships, is either approached with many grains of salt, stated typically in generalized verbal terms, or is not approached at all. Most authors who take a stab in this direction, state something to the effect that: *organisms increase their order, i.e. decrease their entropy, grow, and divide by taking in free energy from their environment*. This definition, however, explains little in terms of purpose in life or mate selection.[55] Moreover, statements as these make little sense in terms of Carnot cycles, working bodies, and Gibbs free energy changes ΔG per system. In other words, for instance, spontaneous chemical reactions *release* free energy from their working system into their environment, only non-spontaneous reactions must take it in.

Lehninger, for instance, argues that the order produced within cells as they grow and divide is more than compensated for by the disorder they create in their surroundings in the course of growth and division. In short, according to Lehninger, 'living organisms preserve their internal order by taking from their surroundings free energy, in the form of nutrients or sunlight, and returning to their surroundings an equal amount of energy as heat and entropy.'[56] This basic assumed thermodynamic evolution principle of growth is found in regurgitated form everywhere.[57]

In 1876, to cite one early example, American civil engineer Richard McCulloch, in his *Treatise on the Mechanical Theory of Heat and its Application to the Steam-Engine*, an early thermodynamics textbook, states, after speaking about the laws of the physical world, that 'there are none that are established on a firmer basis than the two general propositions of Joule and Carnot; which constitute the fundamental laws of our subject.'[58] McCulloch then goes on to show that these two laws may be combined in a single expression [16.3]. McCullen then declares that the applications of these two laws, i.e. the first law of thermodynamics and the second law of thermodynamics, are innumerable. He then states: 'when we reflect how generally physical phenomena are connected with thermal changes and relations, it at once becomes obvious that there are few, if any, branches of natural science which are not more or less dependent upon the great truths under consideration. Nor should it, therefore, be a matter of surprise that already, in the short space of time, not yet one generation, elapsed since the *mechanical theory of heat* has been freely adopted, whole branches of physical science have been revolutionized by it.'[58] Moreover, to clarify, McCulloch states 'the mechanical theory of heat, sometimes called *thermo-dynamics*, is that branch of science which treats of the phenomena of heat as effects of motion and position.'[59]

McCulloch then gives a few examples of what he calls the 'more interesting examples' of the application of these laws in extent and utility. The first example he gives, is physiology wherein he states that 'the body of an animal, not less than a steamer, or a locomotive, is truly a *heat engine*, and the consumption of food in the

one is precisely analogous to the burning of fuel in the other; in both, the chemical process is the same: that called *combustion*.'[60] He then incorporates a discussion of French chemist Antoine Lavoisier's theory of respiration with cycles of digestion and excretion, perspiration, but then contradicts Lavoisier with recent findings, such as internal heat generated by friction, according to the new *theory of heat*, which, according to McCullen, states that 'heat of the body generally and uniformly is diffused instead of being concentrated in the chest.'[59] McCullen then gives an example of the second law, where he states that 'friction, especially in the smaller blooded-vessels, must develop heat. Without doubt, animal heat is thus in part produced.' He then asks 'but whence the expenditure of energy causing that friction, and which must be itself accounted for?'

To answer this question he turns to the mechanical theory of heat and goes on to loosely outline how the heart is what he calls a 'force-pump', which receives blood and sends it to every part of the body, as discovered by English physician William Harvey, that 'acts like the piston of an engine and is dependent upon and consequently due to the cycle of nutrition and excretion which sustains physical or organic life.' It is likely, here, that McCulloch was modeling parts of this argument on that of the famous *Carnot cycle*.[61] In conclusion, he summarizes the physiological version of the first and second laws as such: 'everything physical being subject to the *law of conservation of energy*, it follows that no physiological action can take place except with expenditure of energy derived from food; also, that an animal performing mechanical work must from the same quantity of food generate less heat than one abstaining from exertion, the difference being precisely the *heat equivalent* of that of work.' McCulloch's overview here, to note, is rudimentary in theory, but for its time period quite progressive. In modern terms, we have full-textbooks on these subjects.[53]

In the popular 1954 booklet *What is Life?* by Austrian Nobel-laureate physicist Erwin Schrödinger he famously states that life, contrary to the general tendency dictated by the second law of thermodynamics, decreases or maintains its entropy by feeding on negative entropy and that had he been catering for the physicists alone he would have let the discussion turn on *free energy* instead.[62] It is the more familiar notion in this context. But this highly technical term seemed linguistically too near to *energy* for making the average reader alive to the contrast between the two things

In modern terms, it is free energy rather than entropy, which is a function of the latter [2.1], that takes center stage. In the exceptional 2003 book *Information Theory and Evolution* by Danish Nobel-laureate chemist John Avery, for instance, it is argued that the phenomenon of life, including its origin and evolution, as well as human cultural evolution, has its basis in the background of thermodynamics, statistical mechanics, and information theory; and that the (apparent) paradox between the second law of thermodynamics and the high degree of order and complexity produced by living systems, according to Avery, has its resolution 'in the

information content of the Gibbs free energy that enters the biosphere from outside sources.'[63]

The majority of these statements stem from two turning-point publications at the first quarter 20th century, which successfully applied the generalized equilibrium principles developed by Gibbs to basic chemical processes, in a simple language that chemists could understand, and thus established the foundation of the modern science of chemical thermodynamics.[64] The first was the accessible 1923 textbook *Thermodynamics and the Free Energy of Chemical Substances* by American physical chemists Gilbert Lewis and Merle Randall.[65] This book was responsible for supplanting the millennium-old concept of chemical affinity, i.e. the 'driving force' of the reaction, for the more accurate term free energy (which is comprised of two driving forces in reactions: the *enthalpic drive* and the *entropic drive*), in the English-speaking world.[66] The second was the 1933 book *Modern Thermodynamics by the Methods of Willard Gibbs* by English chemist and thermodynamicist Edward Guggenheim.[67] In this manner, Lewis, Randall, and Guggenheim are considered the founders of modern chemical thermodynamics because of the major contribution of these two books in unifying the application of thermodynamics to chemistry.[64]

Stemming from these founding publications, a number of subsidiary branches of human thermodynamics were developed over the years, which have approached the problem of modeling the dynamics of human social life in essentially generalized verbal terms or 'mathematical isomorphisms', such as in Samuelson's case. These include the science of *psychodynamics*, i.e. the thermodynamics of psychology, and the science of *thermoeconomics*, i.e. the thermodynamics of economics, among other scattered writings and theories, such as Belgian chemist Ilya Prigogine's theory of *dissipative structures*, work for which he won the 1977 Nobel Prize in Chemistry.[68]

More recently, however, a few scientists began to look at the thermodynamic problem, more accurately, from the *human molecular* point of view, in which the thermodynamic systems under study are sets of partitioned-off human molecules in reactive, work-producing, solar-thermally-driven, Carnot cycles. Three scientists to have independently arrived at this basic result are Russian physical chemist Georgi Gladyshev (1977, 1997), American chemical engineer Libb Thims (1995, 2005), i.e. the author of this book, and American computational chemist David Hwang (2001), as discussed below.[69]

Other theoreticians to have begun tackling the problem of understanding human thermodynamic phenomena, not directly in terms of differentials of chemical thermodynamic free energy calculations, but indirectly via verbal arguments on the application of the laws of thermodynamics, free energy, and entropy, etc., to human life, include researchers American Lawrence Chin, *A Thermodynamic Interpretation of History* (1999), American Elizabeth Porteus, *My Twentieth Century Philosophy* (1987) and *Happiness Thermodynamics* (1999), Lebanese-born American-Dane John Avery, *Information Theory and Evolution* (2003), and American Jing Chen, *The*

Physical Foundation of Economics – an Analytical Thermodynamic Theory (2005).[70] In the section to follow, we will skim over a view of these interesting approaches.

History

The first to apply the principles of thermodynamics to human life, specifically at the mental level, was the Austrian psychoanalysist Sigmund Freud, who in 1874 began to affix the laws of thermodynamics, particularly Helmholtz's conservation of force-energy (the first law), to human psychological processes, such as regression, instinct, drive, libido, motivational forces, etc., and in doing so developed psychodynamics, a precursor to human thermodynamics.[71]

In modern terms, *psychodynamics* is the study of human behavior from the point of view of motivation and drives, depending largely on the functional significance of emotion, and based on the assumption that an individual's total personality and reactions at any given time are the product of the interaction between his genetic constitution and his environment.[72] In medical practice, psychodynamics is defined as the systematized study and theory of the psychological forces that underlie human behavior, emphasizing the interplay between unconscious and conscious motivation and the functional significance of emotion.[73] The basic *mental forces* involved in psychodynamics are often divided into two parts: (a) interaction of emotional forces: the interaction of the emotional and motivational forces that affect behavior and mental states, especially on a subconscious level; (b) inner forces affecting behavior: the study of the emotional and motivational forces that affect behavior and mental states.[74]

The basic concept of 'psychodynamics', in short, was seeded with the 1874 publication of *Lectures on Physiology* by German scientist Ernst von Brucke who, in coordination with Helmholtz, supposed that all living organisms are energy-systems governed by the principle of the conservation of energy. During this apical year, at the University of Vienna, Brucke was also coincidentally the supervisor for first-year medical student Sigmund Freud who naturally came to adopted this new 'dynamic' physiology.

Freud mostly used analogies. He would say, for example, that 'by the pressure of an instinct, we understand its motor factor the amount of force or the measure of the demand for work which it represents. The aim of an instinct is in every instance satisfaction, which can only be obtained by removing the state of stimulation at the source of the instinct.'[75] Freud's basic thermodynamic theories on the subconscious, however, are quite elaborate and too lengthy to go into at this point.[76] Those such as Carl Jung, who introduced the conception of *psychological entropy*, Alfred Adler, Melanie Klein, Anna Freud, Eric Berne, Mihály Csíkszentmihályi, and others, later worked to further develop the theory of psychodynamics.[77]

Human thermodynamics, itself, is a relatively new science. The first recorded use of the term *human thermodynamics* as well as that of the *human molecule* was made by Charles Galton Darwin, the Grandson of Charles Darwin, in his terse 1952 book *The Next Million Years*.[78] In this sense, we can rightly say that C.G. Darwin coined these terms.[79] The purpose his book was to use the principles and laws of science to predict the outcome of the future of the human race. He wrote the book essentially, as he says, from memory, as based on a considerable amount of unsystematic reading and thinking on the subject. As to his educational qualifications to justify the writing of such a lofty book, he states that although he makes no claim to being a historian, he has always had a great interest in history and in the biological sciences, and that the final stimulus to write his ideas came from the physical sciences, namely statistical thermodynamics.

To make his historical predictions, as discussed, first he positions the idea of the human molecule and argues that the interactions and collisions of human molecules would actuate in what are called 'conservative dynamic systems'. Moreover, he reasons, the process or evolution of these molecular interactions, i.e. life, would be predictable according to the *laws of statistical thermodynamics*.

Building on this, he rounds of his argument with a discussion on the efficiency of engines and thermodynamics, and states that if we determine 'some kind of ***laws of human thermodynamics***' we shall be more successful in doing good in the world. He concludes by saying that 'I am going to try to see what these laws of human thermodynamics are; of course they cannot be expected to have the hard outline of the laws of physical science, but still I think some of them can be given a fairly definite form.' He reasons that it will be up to someone more skilled in biology than he is to perfect, or perhaps correct, his attempts at a possible formulation of the laws of human thermodynamics. Correctly, to clarify, he should have said someone more skilled in physical chemistry or chemical thermodynamics. In any event, these are excellent suppositions for such a period in history.

The actual number of people who, in one way or another, have made attempts to apply the laws of thermodynamics to the process of human life is too numerous to list in detail in this short history; most, however, can be directly traced to the work of Clausius and his energy change theories associated with the ordering of atomic and molecular systems.[80] Many of these noted scientists have been mentioned previously in chapters three and four. We will only mention a few key players here.

In 1977, Belgian physicist and chemical engineer Ilya Prigogine published his *Self-Organization in Non-Equilibrium Systems: From Dissipative Structures to Order Through Fluctuations*, wherein he noted that when heat is fluxed through a viscous medium, such as silicon oil, coherent 'structures' spontaneously emerge. The prime example being *Bénard cells*, which are hexagonal-shaped liquid columns. He famously calls these 'far-from-equilibrium' dissipative structures, which, as he

argues are models of human life. In other words, according to Prigogine, heat from the sun dissipates into the formation of molecular structures.[81]

In short, Prigogine's theory argues that the human organism is a molecular structure, similar to liquid, column-shaped, hexagonal *Bénard cells,* formed through mathematical operations called *bifurcations* and *fluctuations*, owing to the energy gradient from the hot Sun (10^7K) to cold Pluto (50K), and that it is the laws of *non-equilibrium thermodynamics*, rather than the classical equilibrium thermodynamics, that govern human life.[82] This concept, even though it is logically inconsistent, has been well received, being that no other alternatives before this had been proposed. Austrian-born American physicist Fritjof Capra, for instance, is a big popularizer of Prigogine's theories. In his 1996 *The Web of Life*, Capra argues that Prigogine's dissipative structures are the 'nature of life'. This, however, is not the case. In any event, Prigogine's most popular book is the 1984 *Order out of Chaos*.

Prigogine's dissipative structures theories, interestingly, are even used regularly in the present day to explain life, although often jumbled erroneously together with classical thermodynamics and other disparate sciences, such as chaos theory, or complexity theory, etc., by those who seem not to know any better. In the 2006 textbook *The Thermodynamic Machinery of Life* by Polish physicist Michal Kurzynski, for instance, he states in his opening synopsis that 'living organisms are open thermodynamic systems whose functional structure has developed and been kinetically frozen during the historical process of biological evolution' Moreover, as he argues, as many do, 'a thermodynamics of both non-equilibrium (Prigogine's thermodynamics) and complex systems (complexity theory) is needed for their description' and that the coupling of the biochemical reaction 'processes through a common enzyme [occurs] in the context of free energy (Gibb's thermodynamics) or signal transduction.' Here we see three un-related theories jumbled together as well as the use of the backwards term 'kinetically frozen', as if there were such a thing.

In any event, returning to the decisive year 1977, in opposition to newly christened Nobel Laureate Prigogine, Russian physical chemist Georgi Gladyshev, knowing intuitively that Prigogine was wrong in his *non-equilibrium* thermodynamic evolution theories, proposed an *equilibrium* thermodynamic theory of evolution and human life, theorizing that humans are supramolecular structures that evolve, in a quasi-equilibrium manner, within partitioned hierarchy-structured subsystems, in the direction that tends to minimize the Gibbs free energy of each subsystem, according to the combined law of thermodynamics. He sent a copy of this manuscript to Prigogine to review; Prigogine, however, rejected it.

Later that year, nevertheless, Gladyshev sent a copy of his manuscript entitled 'On the Thermodynamics of Biological Evolution' to the *Journal of Theoretical Biology*. In was published in April of 1978. In this manner, Gladyshev formulated a new branch of science called *hierarchical thermodynamics*, which studies complex heterogeneous systems that exchange matter and energy with the environment.[83] In

short, Gladyshev was the first to apply Gibbs' stability criteria of equilibrium, as embodied in the combined law of thermodynamics [4.24], to the process of social evolution. These efforts came to fruition in 1997 when Gladyshev published his excellent book *Thermodynamic Theory of the Evolution of Living Beings*.

In 1999, American Physician Karlis Ullis, in the book *Age Right – Turn Back the Clock with a Proven, Personalized Antiaging Program*, devotes a whole chapter to what he calls the critical point and the 'theory of human thermodynamics.' The human body, according to Ullis, is an anabolic biomachine and the body's critical point, especially for athletes, is the razor-thin line between training hard and overtraining. Ullis, in short, attempts to correlated entropy with overtraining. Karlis only devotes a few short pages to these ideas, which are mostly crude analogies, but his significance here, is that he is the second person to use the term *human thermodynamics* in functional sense.

The essential start date, however, for the science of 'human thermodynamics', as defined herein, in human chemistry, is November, 2001, a decisive point at which American chemical engineer Libb Thims conceptually solved the application of the Gibbs free energy equation [4.11] to the basic human reproduction reaction [4.34], i.e. that in which two people chemically react to create a child over the course of a number of years. In the month to follow, Thims wrote up a terse outline of this solution and had it reviewed by a number of people, reviews that turned out to favorable.

Seven years prior to this date, in 1995, Thims, then a chemical engineering student at the University of Michigan, who prior to 1992 had never taken a chemistry course (or basically any science or math course), began to wonder why no one had applied the laws of chemical thermodynamics, in particular the Gibbs free energy equation:

$$\Delta G = \Delta H - T\Delta S = (H_f - H_i) - T(S_f - S_i) \qquad [4.26]$$

for use in understanding the prediction and energetics of romantic relationship work calculations of basic human chemical reactions. Put simply, even seven-year-olds intuitively know that love is chemical reaction and as all chemical engineers know, to predict reaction feasibility, one turns to the free energy tables. Hence, it is an obvious, 7-year-old, no-brainer that human reaction relationships can be calculated thermodynamically, given some thought on how to apply the laws and equations quantitatively to human systems. In engineering, this is approach is called *top-down analysis*.[84]

The urge was within him, during these years, to raise his hand in lecture class, to ask something to the effect of: 'how does one use the Gibbs free energy equation and thermodynamic tables to pick the right mate?'; but, for whatever reason, he held his tongue, and instead began to figure out the answer on his own.

In other words, a reaction between people, i.e. human molecules, *Mx* and *Fy*, as they yield work output:

$$Mx + Fy \rightarrow MxFy + Bc \qquad [4.29]$$

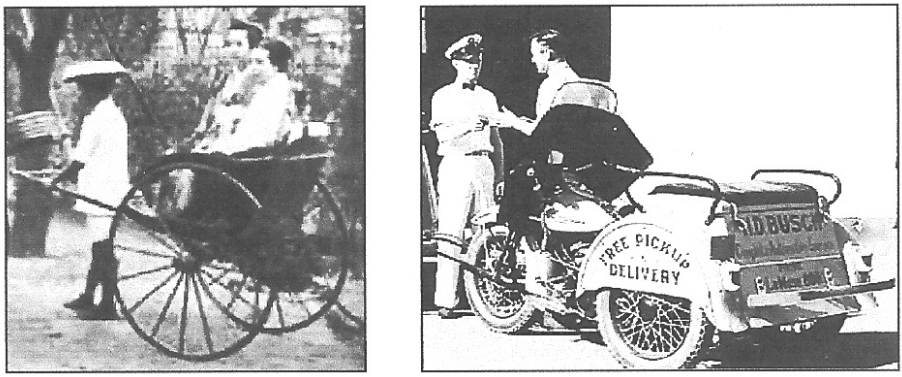
invariably is no different then reactions between molecules such as, for example, the simple molecular species sodium chloride *NaCl* and silver nitrate *AgNO*, in a basic *double displacement reaction*, in which the two compounds, in aqueous solution, exchange elements or ions to form different compounds:

$$NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl \qquad [16.6]$$

Similarly, both of these reactions, again, are no different that any typical *combustion reaction* in which hydrocarbon and oxygen molecules react in combustion engines, such as shown below for methane:

$$CH_4 + 2O_2 \rightarrow CO_2 + H_2O \qquad [6.4]$$

The laws of chemical thermodynamics are the same in all of these reactions. In other words, as human molecules react, over substrate, in the engines of *society* (driven by an external heat source) or as hydrocarbon molecules react in an engine (driven by an external heat source), they each produce useful work output.



A ***human motor,*** i.e. human molecules reacting, and a ***mechanical motor,*** i.e. hydrocarbon and oxygen molecules reacting, to yield work output.

The molecules in a combustion engine perform work because they are arranged or structured within a *drivetrain*, which refers to the group of components that generate power and deliver it to the road surface, water, or air. A drivetrain includes such components as the engine, transmission, driveshafts, differentials, and the final drive, which can be drive wheels, a caterpillar track, a propeller, etc. Likewise, the

working framework of an economic society is the drivetrain for human molecules. As such, the obviousness of the similarity between these reactions, such as [4.29] and [6.24], is clear (e.g. by comparing the energetics of the two photos).

To any modern-day chemical engineer, most will agree that the principles embodied in standard thermodynamic tables, in theory, should be applicable to the calculation of the Gibbs free energy changes related to any basic human chemical reaction, such as those values related to potential mate pairs.[9] In other words, through the combined law of thermodynamics and basic equation modeling using state variables, interpersonal Gibbs free energy values should allow a trained thermodynamicist to pre-calculate whom people are predisposed to scientifically fall in love with, thus saving the average person a great deal of time, frustration, and trial-and-error.[9]

In a similar manner, although approaching the problem of human mate choice selection from a different perspective, that same year, Thims stumbled upon a copy of American evolutionary psychologist David Buss' newly published 1994 book *The Evolution of Desire – Strategies of Human Mating*, possibly one of the best books on mate selection ever written.[85] This further stimulated Thims to read approximately 100 more books, over the years, on evolutionary psychology, sexual selection, on human mating, etc., as a sort of inquisitive personal hobby.

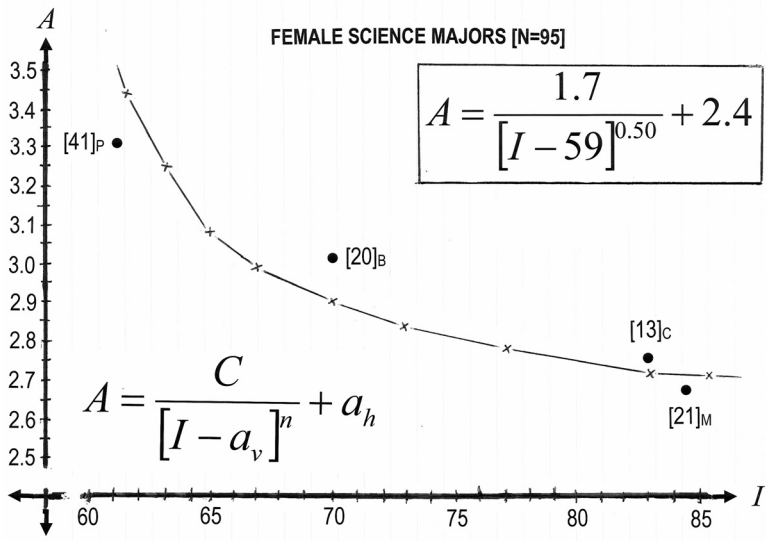
During this period, Thims would often try, in some way or manner, to connect the two separate sciences of chemical thermodynamics and evolutionary psychology, through various ballpark calculations attempted on scratch paper. The basic mental conceptualization of the use or realistic application of [4.11] in human mate reaction prediction, however, remained completely elusive or blank. In other words, to any sharp chemical engineer, on first pass, the quantity '$\Delta H - T\Delta S$' is a visual mystery in terms of how this enthalpy-entropy function relates to human life, externally, i.e. people reacting, falling in love, and producing offspring. It takes a good five years, or more, to get these dynamical quantities through one's head, in terms of what they mean from a human chemical reaction perspective.

In efforts to solve this difficult issue, while simultaneous finishing his course work in chemical engineering as well as preparing for medical school and finishing a second degree in electrical engineering, Thims began to intensely read up on the various ways in which others, in the past, had attempted to apply thermodynamic theory to human life. In short, Thims read book after book on subjects related to this puzzle, while in the process, amassing a rather large 1,000+ book home library (150+ of which are thermodynamics books); this as contrasted with his first year of college, at which point he owned zero books.[86]

Hence, on November 15, 2001, at 3:00 AM, while simultaneously memorizing neuroanatomy and reading Steven Hawking's famous 1996 *An Illustrated – A Brief History of Time*, in which Hawking inversely correlated intelligence with entropy in a verbal description, Thims solved, as a first approximation, the Gibbs free energy

equation's applicability to the human reaction mechanism [4.34]. In short, most agree that the basics of human life boil down to the bonding interactions involving beauty, brains, love (attraction), hate (repulsion), and work, i.e. human purpose or function. Thus, if one correlates human enthalpy with physical beauty, human entropy with the inverse measure of entropy, human free energy with functional work output, love with bond formation, and hate with bond dissolution, then the whole picture clicks together.[87]

Moreover, up to this point, no one had ever properly explained the essential science behind the long-standing joke as to *why beauty and brains don't come in the same package?* In other words, everyone agrees that, on average, the best-looking or hottest people won't typically be found in math class; i.e., statistically speaking, on average, physical attractiveness (beauty) is inversely proportionally to neurological attractiveness (beauty):[87]



Attractiveness vs. Intelligence at UIC

To prove that this inverse pattern exists statistically, in 2002 Thims conducted an 'attractiveness *A* vs. intelligence *I*' study. In this study, to determine if attractiveness is, in actuality, inversely proportional to intelligence, Thims had one group of people rate the physical attractiveness of 2,018 college graduation photos, graduating classes of 1969 and 1972 at the University of Illinois at Chicago, and had a second group of people rate the intellectual difficulty of each degree obtained for the people in those photos. These two data sets were sorted by sex and grouped into similar categories. The results confirmed the theory. In the graduating classes of 1969 and 1972, for example, 670 female students obtained 67 different degrees. By comparing females who obtained science-related degrees, among other related groups, we obtain the plot shown above.[87]

In this plot, P = psychology, B = biology, C = chemistry, and M = mathematics, each with 41, 20, 13, and 21 students, respectively. Similarly, A = physical attractiveness (of group); on a scale of 7.0 = most physically attractive to 1.0 = least physically attractive; and I = intellectual difficulty (of degree); on a scale of 100 = most intellectually difficult to 10 = least intellectually difficult. In sum, by combining the sciences *chemical thermodynamics* with *evolutionary psychology*, one can readily explain these curious statistical patterns in which physical attractiveness is found to be inversely correlated to intelligence or neurological attractiveness.[88]

In short, after seven years worth of puzzle dabbling, via random notes and crude equations on scratch paper, Thims used a sort of tabular plug-n-chug method to solve the problem, at least conceptually. Using [4.11], one variable was changed, while holding the others constant, so to observe its resultant effect on the change in free energy G. The same procedure was done with the other variables, i.e. using 'before' and 'after' values of human enthalpy H and human entropy S, when viewing the base human chemical reaction mechanism with a reaction time of $\tau = 33$ years, i.e. time per generation.[87]

In any event, prior this study, on December 05, 2001, Thims decided it would be in his own interest, i.e. engineering and medical school tuition reimbursement, and society's interest to make attempts at writing up a short booklet to present this solution, having never before had any inkling or desire to write. The original view was that it would take no more than two months to complete the thermodynamic writing project. This, however, turned out not to be the case. From this starting point up, to early 2005, Thims researched on, read about, and wrote up a first-draft 1,000 page, three-volume manuscript on the science of human thermodynamics. During these years, he also began to filter these volumes through various reviewers and editors, locally around Chicago and in Los Angeles, to get feed back.

On 04/27/05, Thims brought the topic to a worldwide audience by first starting *humanthermodynamics.com* and the **Institute *of* Human Thermodynamics** [IoHT], in efforts to provide a simplified free educational website on the history and current theories and topics of human thermodynamics as well as to link up other human thermodynamic researchers worldwide, and then by starting the **Journal *of* Human Thermodynamics** [JHT] in order to provide a free publication forum for those interested in writing articles about human thermodynamics.[89] Their visitor flow and file-size content have been increasing since.[90] By 2007, Thims had finished writing the manuscripts of five books, specifically *Human Thermodynamics VI-VIII*, *Cessation Thermodynamics*, and *Human Chemistry VI-VII*, totaling 1,900 pages, over 500 scientific studies, and a plethora of desperately need new theories and concepts, and then began to filter these books through about 100+ reviewers to test for theoretical appeal and logical cohesiveness.

The reason that the subject of human chemistry was written last, e.g. the website *humanchemistry.net* was started on 04/07/07, and published mass-market style first,

is that the science of human chemistry, in Thims' point of view, should be obvious to both the average person and the trained scientist, and as such, not be in need of an obvious publication. In the acknowledgment section, for example, it was noted that seven-year-olds, such as Jason, agree that all of human life is a process of chemical reactions. Likewise, as mentioned, theories on human bonding abound.[91] In other words, human chemistry is a common-sense subject and should not be in need of a manuscript.

After April of 2005, however, heated debates and arguments began to irrupt between Thims and various trained chemists, engineers, and scientists on the subject of human thermodynamics. Many viewed the idea of a thermodynamics of human life to be some type of farcical pseudoscience.[92] One person with a B.S. in civil engineering commented 'I admit, open systems do exist and can be described with thermodynamics; nonetheless, their application to group dynamics is a major stretch, and modeling human relationships on them involves all sorts of unstated assumptions, for instance that a state function (like Gibbs free energy) even applies, or that they're spontaneous.' Another individual, with a B.S. in physics and chemistry and a Ph.D. in biology and biophysics declared abruptly '*thermodynamics isn't meant to describe human relationships.*' A third person commented 'I don't believe that thermodynamics is any more relevant to human life than to anything else. We don't have *thermodynamics of vegetables or thermodynamics of chairs*, do we?' The term 'snake oil salesman' was even used.

Significantly, on November 24, 2005, one particular individual, an American high school geology teacher, after reading the terse human chemical reaction section of the IoHT's :: *Top 150 Definitions of Love* page, referred to the idea of 'human chemical reactions', particularly reaction [1.1], occurring between 'human molecules' as being:[94]

'good for a laugh, but not much else'

This statement was the straw that broke the camel's back. Upon hearing this, over the following 18 months and 14 days, Thims wrote out the entire subject of human chemistry, straight away, in textbook style, as is found in this book.[95] In other words, this entire book was written (in part) to specifically spite this one particular individual (as well as others like him).

Prior to these events, in 2001, similar to Thims' views, American computational chemist David Hwang, an undergraduate senior at Emory University, published an article titled 'The Thermodynamics of Love' in the *Journal of Hybrid Vigor*, in which he postulated, using an analogical humorous style, that the Gibbs free energy function [2.1] predicts human love in theoretical male *M* female *F* chemical reactions, in which free energy graphical calculations will determine if two people will be energetically perfect a pair or better separate.[96] Hwang states that commonly two

people who fall in love with one another are often described as having a certain *personal chemistry*.[97]

Hwang goes on to state that 'although most people would be quite content to accept this convention at face value, the truth is that the correlation between romance and everyone's favorite branch of the natural sciences runs quite deep.' According to Hwang, 'while the terminology of thermodynamics explains the *spontaneity* of chemical reactions very well, it also applies directly to determining the success of human relationships.'

Hwang postulates a theoretical human chemical reaction where as he states: two elements, 'male' *M* and 'female' *F*, combine to form a new compound called 'couple' *M-F*, as shown by the following reaction expression:

$$M + F \rightarrow M\text{-}F \qquad [4.28]$$

In [4.28], Hwang uses a single dash '–' to represent the chemical bond. He then reminds us that to predict the likeliness that any given chemical reaction will proceed in the forward direction, chemists draw simple curves outlining the energy considerations, in which the y-axis represents free energy *G* and the x-axis represents the progression of the reaction with time, i.e. the reaction coordinate ε.

From these reaction coordinate graphs, according to Hwang, individual human elements, *M* and *F*, with a collective high free energy *G* value are relatively reactive, such as a 'hot' single person, while a compound, *M-F*, with a low value of *G* is likely to be stable, such as a 'warm' married couple. Thus, a reaction in which *G* decreases will favor the formation of the product *M-F* because the state of the products have less free energy than the starting compounds and are more stable.[96] To encapsulate the essential Gibbsian free energy equilibrium principle of thermodynamics, Hwang states the following rule concerning human chemical reactions:

> "If the given male-female reaction has a very negative free energy, then it is expected that the system will spend most of its time together as a strong couple."

Hwang's article is one exceptional paper, not necessarily in terms of rigor (it's only four pages), but in terms of the fact that he *called it like it is* (with lots of humor).

Beyond these base human thermodynamic foundations, there are a number of areas where scientists have been successful, verbally or generally, in applying basic thermodynamic terms and concepts to human life, although, in most cases, not very rigorous as modern chemical thermodynamics requires, with its typical 20-30 page exacting derivations. Here we will touch on a few of the more interesting ones.

Psychodynamics

In science, *psychodynamics* is the application of the principles of thermodynamics to psychology.[98] In more detail, psychodynamics is the use of physics, namely the laws of thermodynamics, *drive*, meaning to impart forward motion to by physical *force*, *energy*, referring to libido, and *entropy*, referring to resistances in the external world mediated by the *ego*, and others, etc., in psychology, especially in relation to the interaction of the conscious and unconscious levels of the mind.

Historically, although many psychologists contributed to the early development of this field, this branch of science resulted owing to a synergy of ideas between Hermann von Helmholtz, Ernst von Brücke, and Sigmund Freud, essentially. In 1859, when Freud was three, his family took him to Vienna to see the publication of Charles Darwin's *Origin of Species*. The following year, coincidently, German experimental psychologist Gustav Fechner founded the science psychology when he demonstrated, in 1860, that the mind could be studied scientifically and that it could be measured quantitatively.[99] These two key men, Darwin and Fechner, had a tremendous impact on the intellectual development of Freud.[100]

In addiction, according to Freudian historian Calvin Hall, from his 1954 book *A Primer in Freudian Psychology*, 'there were other influences that affected Freud even more profoundly'. These influences, according to Hall, came from physics, particularly in 'the great physicist, Hermann von Helmholtz, [who] formulated the principle of conservation of energy.' This principle stated, in effect, that energy is a quantity just as mass is a quantity.[101] It can be transformed but it cannot be destroyed. When energy disappears from one part of a system it has to appear elsewhere in the system. The fifty years between Helmholtz's statement of the conservation of energy and Albert Einstein's theory of relativity, according to Hall, was 'the golden age of energy: thermodynamics, the electromagnetic field, and quantum theory' and these were the primary influences in the development of Freudian psychology.[100]

Hall explains how the founding thermodynamicists, namely 'James Maxwell, Max Planck, James Joule, Lord Kelvin, Josiah (Willard) Gibbs, and Rudolf Clausius', had an influence on Freud and that after studying under Ernst Brucke, who was a close associate with Helmholtz, whom he had worked previously with in the years 1838-42, in the laboratory of the German physiologist Johannes Muller, that Freud 'quickly became indoctrinated by the new dynamic physiology' and that 'he was to discover some twenty years later that the laws of thermodynamics could be applied to man's personality as well as to his body.'[100]

Hence, stemming from the thermodynamic principles of Helmholtz, especially *conservation of force*, based on the principles of thermodynamics of closed systems, Freud proposed that psychological energy was constant, hence, emotional changes consisted only in displacements, and that it tended to rest, towards a point attractor,

through discharge, e.g. catharsis.[102] Psychodynamics, subsequently, according to Freud, studies the transformations and exchanges of psychological energy within the personality.[100] A focus in psychodynamics is the connection between the energetics of emotional states in the id, ego, and superego as they relate to early developmental childhood events and processes. At the heart of psychological processes, according to Freud, is the ego, which he sees battling with three forces: the id, the super-ego, and the outside world.[103]

Hence, the basic 'psychodynamic model' focuses on the dynamic interactions between the id, ego, and superego.[104] Psychodynamics, subsequently, attempts to explain or interpret behavior or mental states in terms of innate emotional forces or processes. In his 1923 *The Ego and the Id*, Freud speaks of *psychical dynamics*, *mental dynamics*, the division of the psychical into the conscious and unconscious, the various *forces* and *work* associated with mental 'states', and the displacements of *mental energy* as they effect their way towards action, etc. This, in short, is basic physics and thermodynamics terminologies applied to psychology.

The term 'psychodynamics', to note, often goes by various names by different authors, but is invariably the same logic, i.e. any application of physics, particularly thermodynamics, to psychology, that can trace its roots to Freud. English psychologist John Bowlby (1969) calls it 'Freud's psychical energy model', Austrian psychologist Carl Jung (1928) calls it 'psychic energism and dynamism', Freud (1923) calls it the 'dynamic view' or 'mental dynamics', and there are many others early than Freud who were digging into this area, e.g. in 1896 German philosopher Theodor Lipps had already distinguished between *psychic energy* and *psychic force*, to cite one of many examples. Moreover, prior to the mid 1970s, approximately, the science of thermodynamics was still referred to by many as either the *theory of heat* or the *science of energetics*, among others. In 1891, to cite one example, Gibbs' *Equilibrium* paper was translated into German by chemist Wilhelm Ostwald, who styled its author the 'founder of *chemical energetics*', which in modern terms means the 'founder of *chemical thermodynamics*', a synonym of the former. Hence, during the early 20th century, the name choice as to what Freud was talking about with all of his unconscious 'driving forces', 'repression', and 'instinct' terms, etc., in relation to physics was not that clear.[105]

In any event, during these decisive years, a young Swill psychiatrist named Carl Jung had been following Freud's writings and had sent him copies of his articles and his first book, the 1907 *Psychology of Dementia Praecox*, in which he upheld the Freudian psychodynamic viewpoint, although with some reservations. That year, Freud invited Jung to visit him in Vienna. The two men, it is said, were greatly attracted to each other, and they talked continuously for thirteen hours. This led to a professional relationship in which the corresponded on a weekly basis, for a period of six years.[108]

Stemming from these interactions, Jung went on to advance the general framework of psychodynamics, but with his own amendments. The mental sphere, according to Jung, having conscious and unconscious parts, is divided up into a number of interacting relatively closed systems. The total set of such mental systems takes in energy via sensor input, which energizes the person; however, the dynamic distribution of these inputs among the various systems is governed by two principles, firstly: the ***principle of equivalence*** (first law) – if the amount of energy consigned to a given psychic element decreases or disappears, that amount of energy will appear in another psychic element. Second, the ***principle of entropy*** (second law) – the distribution of energy in the psyche seeks equilibrium or balance among all the structures of the psyche.[108] Jung modeled these basic psychological energetic principles on the first and second laws of thermodynamics, respectively. The key concepts in Jungian psychodynamics are psychic energy or libido, value, equivalence, entropy, progression and regression, and canalization.

In latter half of the 20th century, psychodynamic principles were successfully employed in the development of such sciences as Anna Freud's *ego psychology,* John Bowlby's *attachment theory*, Eric Berne's *transactional analysis*, and Mihály Csíkszentmihályi *positive psychology* and *flow theory*, to name a few.[109] In addition, applications, such as *psychodynamic psychotherapy*, where clinicians utilize various psychodynamic theories of the unconscious, such as regression, to alleviate mental tensions in clients.[110] Similarly, in recent years, there have been applications such as *cognitive psychodynamics*, which is a blend of traditional psychodynamic concepts with cognitive psychology and neuroscience, resulting is a relatively accessible and sensible theory of mental structure and function.[111] Likewise, *organizational psychodynamics* allowing business leaders, in the midst of self-reflection and corporate restructuring, to delve deeper into the corporate consciousness so to better study the unconscious dynamics of organizational behavior in business.[112]

Thermoeconomics

In science, *thermoeconomics* is the application of the principles and laws of thermodynamics to economics.[113] Thermoeconomics can be thought of as the statistical physics of economic value.[114] Thermoeconomics, is based on the proposition that the role of energy in biological evolution should be defined and understood through the laws of thermodynamics, but in terms of such economic criteria as productivity, efficiency, and especially the costs and benefits, or profitability, of the various mechanisms for capturing and utilizing available energy to build biomass and do work.[115]

Thermoeconomists firstly reason that human economic systems can be modeled as thermodynamic systems and then, based on this premise, attempt to develop theoretical economic analogs of the first and second laws of thermodynamics.[116] In

thermoeconomics, the thermodynamic quantity *exergy*, a synonym for Gibbs free energy, i.e. measure of the useful work energy of a system, is the most important measure of value.[117] To clarify, beginning in 1873 Gibbs derived the mathematics of *available energy* of the body and medium into the form it has today.[118] The physics describing energy has changed little since that time. In 1956, for whatever reason, the term *exergy* was suggested as a substitute for free energy by Slovene mechanical engineer Zoran Rant, in his paper 'Exergy, a new word for technical available work' by using the Greek *ex* and *ergon* meaning 'from work'.[119]

Historically, thermoeconomics is a relatively new science, although it traces its conceptual origins to the early 18th century views of the physiocrats.[120] One of the first publications to discuss aspects of economic activity from an energy perspective was the 1865 book *The Coal Question* by Stanley Jevons, the father of modern notions of utility maximization in neoclassical economics.[120] In the late 20th century, those such as Paul Samuelson, with his *Foundations of Economic Analysis*, and Romanian mathematical economist Nicholas Georgescu-Roegen, with his 1971 *The Entropy Law and the Economic Process,* began to apply basic thermodynamic and statistical-mechanical theory to economics, and others, each helped to further the development of thermoeconomics.[122]

In thermoeconomics, economic systems, when modeled as thermodynamic systems, exchange heat, work, and or mass with their surroundings; in this direction, relations between the energy associated with the production, distribution, and consumption of goods and services can be determined. Economic systems in a society always involve matter, energy, entropy, and information. Moreover, the aim of many economic activities is to achieve a certain structure. In this manner, thermoeconomics attempts to apply the theories in non-equilibrium thermodynamics, in which structure formations called dissipative structures form, and information theory, in which *information entropy* is a central construct, to the modeling of economic activities in which the natural flows of energy and materials function to create scarce resources.[123] In thermodynamic terminology, human economic activity may be described as a dissipative system, which flourishes by transforming and exchanging resources, goods, and services. These processes involve complex networks of flows of energy and materials.

Dollo's law

Dollo's Law is a hypothesis proposed by French-born Belgian paleontologist Louis Dollo in 1890, which states that evolution is not reversible.[124] This law was first stated by Dollo in this way: 'an organism is unable to return, even partially, to a previous stage already realized in the ranks of its ancestors.'[125] A structure or organ, according to this hypothesis, that has been lost or discarded through the process of evolution will not reappear in that line of organisms.

Dollo's law, according to British biologist Richard Dawkins, is 'really just a statement about the statistical improbability of following exactly the same evolutionary trajectory twice, or, indeed, any particular trajectory, in either direction.'[126] Similarly, American evolutionary biologist Stephen Gould viewed the idea less strictly, suggesting that '*irreversibility*' forecloses certain evolutionary pathways once broad forms have emerged; he states, for example, 'once you adopt the ordinary body plan of a reptile, hundreds of options are forever closed, and future possibilities must unfold within the limits of inherited design.'[127]

In April 2007, Rachel Collin, a scientist at the Smithsonian Tropical Research Institute, and colleagues from two Chilean universities announced that snails prove Dollo's Law to be false. They demonstrated that sea snails that have lost the larval stage through evolution can regain it, and vice versa.[128] This logic, however, conflicts with the second law of thermodynamics, which states that all chemical processes, human evolution processes included, are not reversible. In other words, evolution, invariable, is *irreversible* as defined by the thermodynamic *arrow of time*.[129] This section, to note, is simple an interesting aside.

Rossini's political thermodynamics

In 1971, American thermodynamicist Frederick Rossini, who is known for his work in chemical thermodynamics, used the combined law of thermodynamics to understand the paradox between freedom and security in social life, during one part of his Priestly Medal Address.[130] The Priestly medal is the highest honor conferred by the American Chemical Society and is awarded for distinguished service in the field of chemistry.[131] Established in 1922, the award is named after Joseph Priestley, the discoverer of oxygen who emigrated to the United States of America in 1793.[132]

Biographically, in 1920, at the age of twenty-one, Rossini entered Carnegie-Mellon University in Pittsburgh, and soon was awarded a full-time teaching scholarship. He graduated with a B.S. in chemical engineering in 1925, followed by an M.S. degree in science in physical chemistry in 1926.[133]

During these years, after reading Lewis and Randall's classical 1923 textbook *Thermodynamics and the Free Energy of Chemical Substances* he wrote to Gilbert Lewis and as a result, he was offered a teaching fellowship at the University of California at Berkeley. Among his teachers were Lewis and William Giauque.[133]

Lewis, to review, is a famous American physical chemist known for his 1902 *Lewis dot structures*, his 1916 paper 'The Atom and the Molecule', which is the foundation of modern valence bond theory, developed in coordination with Irving Langmuir, his 1923 textbook *Thermodynamics and the Free Energy of Chemical Substances*, written in coordination with Merle Randall, one of the founding books in chemical thermodynamics, and for coining the term 'photon', in 1926, for the

smallest unit of radiant energy.[134] In short, Lewis is one of the key founders of modern chemical thermodynamics and in science in general.

Giauque, a Canadian-born American chemist, who is similar to Lewis in stature, entered the College of Chemistry at Berkeley in the late 1910s where he received a Bachelor of Science degree in chemistry, with honors, in 1920. Although he entered university with an interest in becoming a chemical engineer, he soon developed an interest in research under the influence of Lewis. Due to his outstanding performance as a student, he became an Instructor of Chemistry at Berkeley in 1922 and after passing through the various grades of professorship, he became full Professor of Chemistry in 1934.[135]

During his research at Berkeley, he became interested in the third law of thermodynamics as a field of research during his experimental research for his Ph.D. research under Professor G.E. Gibson comparing the relative entropies of glycerine crystals and glass. The principal objective of his researches was to demonstrate through range of appropriate tests that the third law of thermodynamics is a basic natural law.[136] In 1926, he proposed a method for observing temperatures considerably below one Kelvin. His work with D.P. MacDougall, between 1933 and 1935, successfully employed them.

He also developed a magnetic refrigeration device of his own design in order to achieve this outcome, getting closer to absolute zero than many scientists had thought possible. This trailblazing work, apart from proving one of the fundamental laws of nature led to stronger steel, better gasoline and more efficient processes in a range of industries. His researches and that of his students included a large number of entropy determinations from low temperature measurements, particularly on condensed gases. The entropies and other thermodynamic properties of many gases were also determined from quantum statistics and molecular energy levels available from band spectra as well as other sources. His correlated investigations of the entropy of oxygen with Herrick L. Johnston led to the discovery of oxygen isotopes 17 and 18 in the Earth's atmosphere and showed that physicists and chemists had been using different scales of atomic weight for years without recognizing it.[135] In 1949, owing to his achievements, Giauque won the Nobel Prize in Chemistry for his studies in the properties of matter at temperatures close to absolute zero.[136]

This thermodynamical platform, i.e. Gibbs, Lewis, Randall, and Giauque, is that upon which Rossini was built. Moreover, Rossini's doctoral dissertation on the heat capacities of strong electrolytes in aqueous solution was supervised directly by the Randall, one founders of modern chemical thermodynamics.[137] His Ph.D. degree was awarded in 1928, after only 21 months of graduate work, even though he continued to serve as a teaching fellow throughout this entire period.

Randall, to review, was an American physical chemist famous for his work, over the period of 25 years, in measuring Gibbs free energy calculations of compounds with Gilbert Lewis. Together, their 1923 textbook *Thermodynamics and the Free*

Energy of Chemical Substances became a classic work in the field of chemical thermodynamics. Based on work by Gibbs, it was known that chemical reactions proceeded to an equilibrium determined by the free energy of the substances taking part. Using this theory, he and Lewis spent several decades determining free energies of various substances in reactions, such that resultantly the published results of their studies formalized chemical thermodynamics. Their influential 1923 textbook, according to the Belgian thermodynamicist and Nobelist Ilya Prigogine, led to the replacement of the term 'affinity' by the term 'free energy' in much of the English-speaking world.[138]

Upon this great pyramid of chemical thermodynamics knowledge, in 1950 Rossini published his exceptional textbook *Chemical Thermodynamics*, which he dedicates to Lewis, who, as he says on the opening page, is the 'inspirer of many to travel the broad highway of thermodynamics.'[139]

In his 1971 Priestley Medal address, to show how governments are regulated by the laws of chemical thermodynamics and how there formulations may help to shed light on the contradiction between national security and personal freedom, Rossini begins by substituting a simplified version of [11.10] into [4.11], to arrive at:

$$\ln K = -\frac{\Delta H^\circ}{R}\left(\frac{1}{T}\right) + \frac{\Delta S^\circ}{R} \qquad [16.7]$$

He then educated his audience to the fact that in [16.7], K increases with increase in ΔS°, as well as with a decrease in ΔH°. He states that an increase in ΔS° comes 'with *increase in randomness*, leading to greater *freedom* in the system' and that a decrease in ΔH° comes 'with *increase in the energy of binding* of the atoms in the molecular structure, leading to greater *security* in the system.' In this scenario, he is correlating atoms to humans, the security of the system to the security of the nation state, ΔH to social binding, and ΔS to social order.[130]

Rossini continues, by noting that these are opposing factors in the evaluation of the equilibrium constant K, and hence, for a given temperature, as he states, 'the final state of equilibrium for the system is a compromise between the *freedom term* $\Delta S^\circ/R$ and the *security term* $-\Delta H^\circ/RT$.' Subsequently, according to Rossini, 'here we have an interesting picture derived from our science of thermodynamics,' namely that 'equilibrium or stability is a compromise between freedom and security.' In using the term security, he is referring to the state when 'one is secure and safe in his person, in his family, in his home, in control of his property, on the streets, and on his travels.' Freedom, according to Rossini, means the privilege of doing whatever one wants to do. As he notes, however, 'in our civilized society, we have come to believe in behavior according to natural law, that one can do whatever he wishes so long as he does not abridge or infringe upon the rights and privileges of others' and this means that we live 'with some kind of rational law and order'.[130]

The point Rossini attempts to make in connecting the rigorous combined law of thermodynamics to the paradox between freedom and safety, as he says, is that 'one cannot have a maximum of freedom and a maximum of security at the same time' and that 'if there is a maximum of freedom, there will be zero security.' In other words, in a state of total freedom one can do whatever they wish, e.g. injure others, steal, covet, etc., whereas in a state of total security, there will be no freedom, and hence there is trade-off in nature between freedom and security. He reasons that the best option is to trade off between the two to find a good balance, namely that a country should establish the necessary amount of security so to instill a certain level of harmony and happiness, through observance of an appropriate amount of law and order.

Although we cannot tell for sure how the audience reacted to these suppositions, being that there seem to be no immediate follow-up reaction publications, we might reason that the audience reacted with an inquisitive curiosity. In any event, the issue sat mute for some 35 years. In 2006, however, a chemistry professor named Harold Leonard published an article titled 'Chemical Thermodynamics in the Real World' in the January 2006 issue of the *Journal of Chemical Education*, in which he made the suggestion that Rossini's inquisitive 1971 political and governmental thermodynamic views might help the world leaders better understand terrorism in the post 9/11 world.

For some, this was an obvious correlation, for others it was an anathema. To elaborate, in Leonard's letter he supported Rossini's use of thermodynamics, to better understand terrorism, as well as freedom and security.[140] Leonard states that one of the world's greatest challenges at present is 'to find a formula for fighting terrorism, while preserving civil liberties.' He notes that the March 2005 anti-terrorism conference in Madrid was designed specifically to address this problem. As a potential solution to this paradoxical problem, Leonard suggests that we turn to the social freedom-security thermodynamic ideas of Rossini.

The following month, in response to Leonard's suggestions about the use of Gibbsian-Rossini thermodynamics to better understand terrorism, a follow-up letter was published, in the same journal, by American physical chemistry professor John Wójcik, at Villanova University, Philadelphia, Pennsylvania, titled 'A Response to Chemical Thermodynamics in the Real'.[141] In this very abrupt letter, Wójcik ridicules Leonard for his suggestion. He starts out his response-letter with 'Leonard has given us a good example of anthropomorphism in chemistry'. From here, his letter goes down hill where he argues that Leonard is wrong for naively thinking that chemical thermodynamics applies in human life.

Now, Wójcik certainly has some set of balls for going up against figureheads such as Gibbs, Lewis, Randall, Giauque, and Rossini, among others. To this end, we give him credit for speaking his mind. Yet, as Rossini is not here to give his input, as he passed in 1990, here we will clarify the matter.

Wójcik continues, 'the concepts of freedom and security, like order and randomness, were parts of our cultural heritage long before modern thermodynamics was formulated.' This statement is essentially meaningless. Wójcik then tells us that entropy was defined 'solely in response to the need to explain certain modern experimental observations.' This is also incorrect. Entropy was defined in 1854 by Rudolf Clausius to explain *irreversibility* in engine cycles.[142] He then states 'it was never necessary to invoke concepts like *freedom* and *security* to systematize these same experiments.' Wrong again.

In statistical thermodynamics, a *degree of freedom* is a single scalar number describing the classical microstate of a system, i.e. the translational, vibrational, rotational, and excitational states of the individual atoms and molecules comprising a thermodynamic system.[143] Likewise, from a second perspective, entropy is a direct measure of the 'freedom' of any molecular system. At absolute zero of temperature of temperature, the atoms and molecules of a thermodynamics system will have perfect order, small or near-zero entropy measures, will have a near-zero amount of movement and activity, will have great attachment security in their mutual level of crystalline bonding, and hence will have little translational freedom. Conversely, at higher temperatures, atoms and molecules of a thermodynamics system will have less order, larger entropy measures, will be moving with a great degree freedom, and will be weakly bound to each other, in possession of less security.[144]

In any event, in spite of the fact that Wójcik is a physical chemistry professor and, as such, should know these basic thermodynamic facts; he continues, with his, error-filled, completely backwards response-letter, 'while there is freedom for which one might die to defend, it is certainly not the freedom of entropy.' Moreover, in what has to be one of the most ignorant statements ever made, he says, while 'such anthropomorphic associations might help some students absorb abstract concepts; they certainly are not part of the conceptual framework of science'. If there were a word in the English language to state the equivalent of 'completely wrong to degree of infinity', that word would characterize Wójcik's point of view.

We certainly apologize to Wójcik for using him as a scapegoat, as there are hundreds if not millions like him in the scientific community, but someone has to set the record straight for the betterment of humankind. Directly, without getting too technical, there are approximately eighteen physical laws of the universe, that the average person should have supposedly learned in school:[145]

Fluid mechanics

- Archimedes' principle

Force, mass, and inertia

- Kepler's three laws of planetary motion
- Newton's three laws of motion
- Newton's law of universal gravitation

Heat, energy, and temperature

- Newton's law of cooling
- Boyle's law
- Law of conservation of energy
- Joule's first and second law
- The four laws of thermodynamics

Quantum mechanics

- Heisenberg's uncertainty principle

Wójcik wishes to argue, as many do, that humans are exempt from these laws. This, however, is not the case. Humans are molecules. All molecules abide by these laws.

In any event, in continuation with Wójcik's letter, he states 'the danger of such anthropomorphisms is that we really come to believe that there is substance in them. In this particular case, there is the danger that true human freedom will be reduced to some sort of physical freedom on the same par with entropy.' Here again, Wójcik is self-fueling himself with blind ignorance. To quote again from the great Goethe:

> "None are more hopelessly enslaved than those who falsely believe they are free."

Wójcik continues 'there is some danger that some will think that true human freedom can be measured in terms of some sort of calculus of simultaneous maximums and minimums' and what is by far the worst statement in his entire spiel, he says 'worst of all, there is some danger that *chemical thermodynamics* will have ascribed to it a power that it simply does not have, namely, the power to explain the human condition.' This statement is as false as it can get. Correctly, not only does chemical thermodynamics have the power to explain the human condition, the laws of chemical thermodynamics are what make, break, and govern the human condition.

In conclusion of his letter, in which he insecurely uses the word 'danger' three times, Wójcik says it would be wise to 'purge' these anthropomorphic associations from science, 'let chemistry solve the problems for which it was created', and says 'let true wisdom solve the problems of the human condition.'

In a follow-up letter to this 'Rossini / Leonard / Wójcik debate', called 'State Functions vs. State Governments', printed in the June 2006 issue of the *Journal of Chemical Education*, Todd Silverstein, a chemistry professor at Brandeis University, begins by saying 'I found the discussion by Leonard, Rossini, and Wójcik of the validity of thermodynamic anthropomorphisms to be quite fascinating.' He says, in summary of Wójcik's letter, 'although Wójcik's point is well-taken, I do not agree that such "loose thinking" should be "purged" from science altogether. A well-drawn analogy between two surprisingly dissimilar concepts can not only be helpful in the classroom, it can be pleasing and instructive on its own merits, as long as one is cognizant of its limitations.'[146]

Silverstein continues with his opinion, 'on the surface, Rossini's analogy relating enthalpy, entropy, and the equilibrium constant to freedom and security in the modern nation-state seems like a good example of an unusual and instructive comparison.' He summarizes Rossini's paper as such 'using the thermodynamic conclusion that (a) a reaction's spontaneity (or K_{eq}) increases when either ΔH gets more negative (stronger security) or ΔS gets more positive (more freedom), Rossini analogized that (b) *one cannot have a maximum of freedom and a maximum of security at the same time*.' 'Sadly', as Silverstein reasons, 'point (a), although true, does not support point (b), not even in the limited realm of chemical thermodynamics, much less in the broader realm of political governance.'[146] Silverstein raises some interesting points, but Rossini's basic argument still holds. One can easily re-argue Rossini's point from any number of thermodynamic views, e.g. the third law of thermodynamics.

Silverstein continues, 'Rossini's point (b), from above, is that in any thermodynamic system, a negative ΔH or a positive ΔS can be maximized, but never both.' Then he states 'this conclusion is only true, however, if K_{eq} is constant; of course K_{eq} (and $\Delta G°$) are only constant if reactants and products and all reaction conditions are identical.'

Here, Silverstein is missing the point. Energy and entropy measures are what determine system behavior, i.e. the level of spontaneity and work output of the system. To review, according to Gibbs, the comprehension of the laws which govern any material system is greatly facilitated by considering the energy and entropy of the system in the various states of which it is capable. This simple logic applies for all molecular system, even systems of human molecules regulated by politics and governmental laws.

Rossini's point is that enthalpy and entropy are the two competing driving forces in chemical reactions. Each time a system's entropy is lowered, e.g. by supercooling techniques, during each progressive step a greater and greater amount of energy is required, a phenomenon related to the fact that absolute zero cannot be reached. In other words, one cannot make a hot ordered system. This is what Rossini is getting at. To cite one example, when the pilgrims and settlers first came to America in the 16th and 17th centuries, in search of freedom from government rule and religious persecution, they found it; yet in their early years they were not secure in their nation-state, and hence struggled externally (attack) and internally (civil war) to obtain a measure of balanced security.

Next, and interestingly, as Silverstein states, that Rossini does not specify, in his political governance thermodynamic system, the 'reactants' and 'products'. Thus, Silverstein says 'let us assume, for argument's sake, that the *reactants* are citizens living under an initial system (i) of political governance, and the *products* are citizens living under a final system (f) of political governance. Then Rossini's argument is that for different final systems of governance (f_1, f_2, f_3, etc.), $\Delta H°$ and

$\Delta S°$ for the change in political systems can vary, but always in opposite directions.' Here, although it is nice to see a physical chemist discuss the conception of human reactants and products, Silverstein is subtly adding in words and suppositions that Rossini did not make. Moreover, a true thermodynamical analysis of a political-governmental system would require far more detail of reactants and products as well as species migration than can be discussed in a Priestley Medal lecture.

Before even attempting a thermodynamic analysis of a human molecular political-government system, for instance, one has to define an '*hmol*', i.e. a 'human mole', being that thermodynamic calculations are based on per unit mol of species. In small chemical system terms, one mole is the number of atoms in a 12-gram sample of carbon 12, which equals 6.022×10^{23} atoms or molecules of the same species. In human terms, firstly, one has to divide the world's population of human molecules into species sets, based on mate recognition systems. One way to do this is per country, state, or region, etc. People, on average (neglecting cross-cultural bindings), will tend to neurologically-favor a mating with those from their own country, owing to similarity of common culture and heritage, even though they may physically-favor an outer country mating. Hence, Americans, on average, will tend to mate with Americans, Russians with Russians, Chinese with Chinese, etc. This has to do with entropy binding tendencies, i.e. a binding of two human molecules that have similar learned cultural behaviors in common will be more energetically favored. Next, within one country of species, e.g. American species, one can base the calculation of an *hmol*, for example, on a 12-kilometer sample of American molecules, which (in cities) equates to about 3×10^3 molecules. One can then calculate system free energy changes per unit *hmol*, i.e. the amount of work produced by 3,000 human molecules in a solar Carnot cycle reaction evolution. One can then correlate these bulk measures to average bond energies per family or relationship, using models such as the dodecabond model or others. Methods such as this can then relate average inter-molecular Gibbs free energy bond distinctions to bulk system free energy changes and hence to quantities such as gross national product, politics, and government, etc.

In any event, in continuation with Silverstein's letter, he states 'if, relative to political system *i*, *f* features increased personal freedom (positive $\Delta S°$), then *f* must also feature decreased security (positive $\Delta H°$). Conversely, if *f* features increased security (negative $\Delta H°$), then *f* must also feature decreased personal freedom (negative $\Delta S°$). In other words, Rossini seems to believe that $\Delta H°$ and $\Delta S°$ must have the same sign.' Here again, Rossini did not say this. Rossini means that, given some rigorous thought, values are enthalpy and entropy change could be measured for different political systems, and that a wise politician would choose the best thermodynamic parameters to yield the desired political reaction, i.e. one that is, in Rossini's words, balanced between 'the necessary amount of security so to instill a

certain level of harmony and happiness, through observance of an appropriate amount of law and order.'

In sum, the point that Silverstein is missing is that in a thermodynamic political system, the differential form of the Gibbs free energy, would be immensely more complicated then in Rossini's superficially skimmed lecture analogy overview. A full thermodynamic governing equation for a given governmental system would need to take into account the flows of species into and out of the system as well as external generalized forces acting on the system, e.g. political pressures from other countries, etc.

Such an outline as this, to note, was originally detailed by the Russian physical chemist Georgi Gladyshev in his 1977 *Journal of Theoretical Biology* article 'On the Thermodynamics of Biological Evolution', as summarized by [5.2] and [16.11].[147] Expression [5.2] states that, in a social system, for instance, that the regulatory and evolutionary behaviors of the working system, delineated by its spatiotemporal boundary, will evolve in such a manner that a decrease in the total Gibbs free energy for that dynamic system will actuate, per the combined law of thermodynamics for isothermal, isobaric system. In other words, political systems will tend to evolve in such a direction so as to drive working potentials down per relaxation window.

Second, as stated in his 1997 book *Thermodynamic Theory of the Evolution of Living Beings*, in more advanced analysis of any generalized human reaction system, we would used a more rigorous version of the combined law of thermodynamics.[148] In particular, Gladyshev states 'as a rule, modern thermodynamics studies simple or complex systems with similar processes taking place in a single fixed time scale, in which, usually, the processes are localized in a one or several hierarchies.' However, as he continues, 'the processes in real systems usually imply complicated transformations involving structures of various hierarchies and related to different time scales.' Thus, as he says, 'in *macrothermodynamics*, i.e. the thermodynamics of complex hierarchic natural systems, we use the commonly known equation combining the first and second laws of thermodynamics for complex closed systems where physical-chemical processes take place:

$$TdS \geq dU + PdV - \sum_{k} X_k dx_k - \sum_{i=1}^{k} \mu_i dm_i \qquad [16.8]$$

where T denotes temperature, S the entropy, U the internal energy, P the pressure, V the volume, X_k any generalized force except pressure, x_k any generalized coordinate except volume, μ_i the chemical potential, m_i the mass of the *k-th* substance, which can be replaced by the number of moles, and in which the equality sign relates to the case of reversible changes (ideal reactions), and where the inequality sign describes irreversible processes (real reactions).[119] Each of these quantities can be defined in human molecular terms. Gladyshev defines these two expressions, when applied to evolving human chemical reaction systems, as *sociological thermodynamic*s.

Here, as we see, in a full political-governmental thermodynamic analysis, we have to define systems in great detail, using the full version of he combined law of thermodynamics (total energy balance on the system), taking into account all factors that affect the energy (the first law) and the entropy (the second law) of the system. In sum, whether we're talking about molecules in a test tube or human molecules in a pool floating in a tube, the laws of chemical thermodynamics are one and the same and apply equally and absolutely.

Interesting, in response to this letter by Silverstein, Leonard replies back in a second letter. He says 'I was pleased to see the response by Silverstein to my letter. I support his conclusions completely, especially that: *a well-drawn analogy between two surprisingly dissimilar concepts cannot only be helpful in the classroom, it can be pleasing and instructive on its own merits, as long as one is cognizant of its limitations.*' Lastly, Leonard says, 'we can assume that Rossini may have used this analogy in his teaching, as I did for over 30 years, as well as in his Priestley Medal Address.'[150]

Gladyshev's hierarchical thermodynamics

Hierarchical thermodynamic is the application of Gibbsian thermodynamics to the study of complex heterogeneous chemical and biological systems.[151] A major focal point in hierarchical thermodynamics is system determination. In the extended-time, general scheme, of a biogeochemical world, all chemical and biological systems are open to the flow of matter and energy, between each system and its surroundings. In this case, for any given system, the general first law energy balance for any open system in which both mass contents and energy contents change temporally is:

$$\frac{dE_{sys}}{dt} = \sum_i \dot{Q}_i + \sum_j \dot{W}_{t,j} + \sum_e \dot{m}_e \left(h_e + g \cdot z_e + \frac{1}{2} c_e^2 \right) - \sum_a \dot{m}_a \left(h_a + g \cdot z_a + \frac{1}{2} c_a^2 \right)$$

in which dE_{sys}/dt is the temporal change of the internal energy of the system, $\dot{Q}_i$ the heat flow over the system border, $\dot{W}_{t,j}$ the full load current (technical work) over the system border, $\dot{m}_e$ the mass flow into the system, $\dot{m}_a$ the mass flow from the system, h the specific enthalpy, $g \cdot z$ the specific potential energy, where z is the height over a reference level and g is the acceleration due to gravity, and $(1/2)c^2$ the specific kinetic energy, with a speed c.[152] We can then substitute the second law [3.10] into this expression $Q = TS$ to remove the difficult heat flow term and then calculate the *conditions for equilibrium* during each Carnot cycle, i.e. daily sun-cycle.

In this manner, we have the total evolution of the earth as the energy E_{sys} of each system changes per evolution. Within the evolution of the earth, however, one can focus on the evolution of working biospheric subsets as separate thermodynamic systems, i.e. *working bodies* in the Clausius sense, in which mass flow terms can be neglected to a good approximation.[153] Within systems of the biosphere, then, one

can then focus on spatial-temporal *particular evolutions* (evolution windows), which are subsets of the general evolution.[154] This logic describes a thermodynamic model of biological evolution based on macrophysical and a hierarchy of thermodynamic rules and principles. This development draws on the conclusion that the evolution of life forms can be explained without implementing the concepts of dynamic self-organization or dissipative structures of the non-equilibrium thermodynamic Ilya Prigogine variety.[155]

The basic structure of hierarchical thermodynamics was formulated originally in 1977 by Russian physical chemist Georgi Gladyshev and then expanded on over the following several decades. Gladyshev is a thermodynamicist known for his Gibbs free energy thermodynamic theories of evolution, for his anti-aging theories of foodstuffs, and is one of the founders of modern human thermodynamics.[156]



Georgi P. Gladyshev – founding human thermodynamicist

He is the author of more than five hundred scientific papers. His seminal article is the 1978 'On the Thermodynamics of Biological Evolution' published in the *Journal of Theoretical Biology*.[154] Interestingly, at the time of this publication, Gladyshev's thermodynamic evolution theory was considered rather controversial.[157] In recent years, however, many authors have begun to correctly utilize a Gibbs free energy perspective of evolution.[158]

Gladyshev was born on 19 September 1936 in Alma-Ata, Kazakhstan, he graduated from the Chemistry Department of the State University in Alma-Ata in 1959 and received the Degree of Candidate of Science (Ph.D.) in 1962 and a Doctorate Degree in polymer chemistry in 1966.[159] He became Professor of physical chemistry in 1969 and in 1970 Chief of the Laboratory at the Institute of Chemical Physics of the USSR (Russian) Academy of Sciences in Moscow.[160]

In hierarchical thermodynamics, a general evolution system is represented as a combined set of subordinate subsystems related hierarchically to each other by their stability position in evolutionary space and time, i.e. structurally, spatially, in a space-time hierarchy.[151] In short, the central notion of hierarchical thermodynamics is the focus on partial evolutions (the *i-th* process), i.e. the aggregation of the k_i-*th* component of the system participating in the reaction process *i* on the level *j*. Thus, a hierarchic thermodynamic system is a classical thermodynamic system consisting

of hierarchic subsystems that are related to each other by structure and in which there may be subordination, and possible migration transitions from lower levels to higher levels, and converely.[163] This logic is embodied in what Gladyshev defines as the *law of temporal hierarchies*, which reasons that 'any living system of any temporal hierarchical level in a normal state has a thermostat, i.e. a surrounding medium that is characterized by slightly changing average values of thermodynamic parameter'.

In simple terms, life systems (e.g. a beehive or a bacteria colony), in the biosphere tend, on average, to break up into stability-focused, spatial-temporal subsystems (e.g. a membrane-enclosed cell within a bacteria), i.e. selective molecular collectives, in which particular localized evolutions occur. The cell is one example; life in the cell is unique onto its own. The country is another example; life within the country is unique onto its own. A pond is another example; life within a pond is unique onto its own. Each subsystem will have its own boundary and unique or particular evolution life. The justification of this hierarchy principle is connected with the phenomenon of metabolism and the exchange of matter and energy between adjoined hierarchies. Lower-level hierarchical molecular structures are often reproduced in a medium of higher-level hierarchical molecular structures during the lifetime of the latter. Thus, we have: $t^{i} << t^{i+1}$.

As a rule, modern thermodynamics studies simple or complex systems with similar processes taking place in a single fixed time scale. Usually, the processes are localized in one or several hierarchies. However, the processes in real systems usually imply complicated transformations involving structures of various hierarchies and relating to different time scales. In this situation, we use the *full differential* equations and characteristic functions defined for macrothermodynamics, i.e. thermodynamics of *complex hierarchic* natural systems at constant temperature and pressure, such as [16.8].[164]

In such hierarchic systems, where equation [16.8] is used, not only do chemical reactions take place but also transformations between the structure-elements of other *j*-th hierarchic levels (*i*-th partial evolution). Moreover, let the reagents of each *i*-th evolution condense into the particles or species of the *i*-th evolution phase a structure of higher level of substance organization. In their turn, the latter are reagents of the next, (*i+1*)-th, partial evolution. The order of the partial evolution, *i* and of the structure hierarchy, *j* corresponds to the hierarchy order of the reagents. Transformation of similar reagents of some hierarchic level (*j*) into similar reagents of the next hierarchic levels (j+1, j+2, ...) can be represented as using a system of bi-directional two-way transition reactions arrows. This law is based on the observation that different structures delineate into different classifications of separate yet connected reacting systems distinguished by life-span *(t)*:

$$... << t^{mol} << t^{cel} << t^{org} << t^{pop} << ...$$

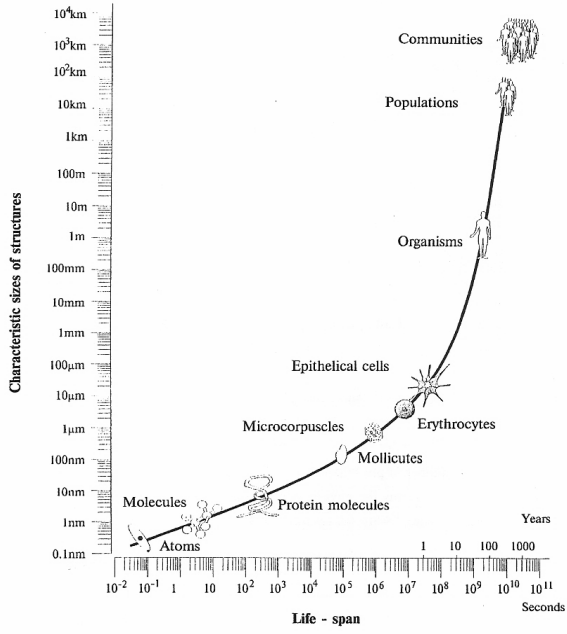
where t^i is the average lifetime of the molecular structures of the lower temporal hierarchical level and t^{i+1} is the average lifetime of molecular structures of higher temporal hierarchical level. This law justifies the use quasi-closed quasi-equilibrium thermodynamic models to investigate open living systems.

These spatial-temporal system distinctions are important in justifying a basic Gibbsian thermodynamic analysis of human life. In making this distinction, we now theoretically define, subgroup, or compartmentalize different interactive reactive living systems into separate yet energetically connected quasi-equilibrium hierarchic thermodynamic systems that tend to be separated in space and or with respect to the time needed for the relaxation to equilibrium, as diagramed above.

In addiction to Gladyshev's spatial hierarchy division of the biosphere, he established the logic that, in the process of ontogenesis, as well as phylogenesis and evolution, the specific value of the Gibbs function of formation of supramolecular structures of the *ith* organism tends toward a minimum, as defined by the following integral limit:

$$G = \frac{1}{V}\int_0^V \frac{\partial G}{\partial m}(x, y, z)dxdydz \rightarrow \min \qquad [5.2]$$

where V is the volume of the system; m is the mass of the identified *micro-volumes*; x, y, and z are coordinates; '—' implies we are using the specific value (relating to the *macro-volume*) of G; 'im' signifies a inter-molecular or supra-molecular structure; and '~' stresses the heterogeneous character of the system. These micro-volumes, per unit lifespan, are diagrammed below:



Gladyshev's spatial-temporal hierarchy diagram

The verbal statement of expression [5.2] in reference to evolution is a gigantic step of thermodynamic logic towards the successful thermodynamic modeling of human life. On these cogent thermodynamic views, Gladyshev established the *principle of substance stability,* which describes the tendency or trend of natural systems to seek local and general equilibria at all temporal and structural levels of the organization of matter. These tendencies derive from the second law thermodynamics, specifically the Clausius–Gibbs variation, in coordination with the *Le Chatelier–Braun principle*. In short, it boils down to the following:

> **Principle of substance stability:** during the formation or self-assembly of the most thermodynamically stable structures at the highest hierarchical level (j), e.g., the supramolecular level, Nature, in accordance with the second law, spontaneously uses predominantly the least thermodynamically stable structures available from a given local part of the biological system, belonging to a lower level, i.e. molecular level (j-1), and incorporates these unstable structures into next higher level, i.e. supramolecular level (j).

The justification for this principle is proved on a quantitative basis as applied to the molecular and supramolecular structural levels of biological tissues, such as occurs in species evolutions in gas-liquid chromatography.[165]

Our agreement with this Gladyshev's free energy minimization tendency theory or principle is strengthened by acknowledging the existence of near uniformity of acceptance of this principle in the learned scientific community. In physical chemist Sture Nordholm's 1997 *Journal of Chemical Education* article 'In Defense of Thermodynamics: An Animate Analogy', for instance, we are told that in nature, where we consider a small subsystem of fixed volume exchanging energy with its surroundings acting as a thermal reservoir, that the corollary of the second law states that: 'nature seeks to minimize the free energy G of a subsystem.' Similarly, according to French thermodynamic geologists Raymond Kern and Alain Weisbrod, from their 1967 *Thermodynamics for Geologists*, the second law of thermodynamics for earth systems states that 'when a system evolves naturally, i.e. undergoes a natural process, in an isothermal manner at constant volume or constant pressure, its free energy or free enthalpy always decreases'. In other words, at constant T and constant P, the relation '$\Delta G < 0$' is the criterion of spontaneous evolution for subsystems in the biosphere, as Gladyshev established in 1977 for human systems as well as biological system, or geological systems, etc.

In this manner, the law of temporal hierarchies and the principle of substance stability, which establishes a predominant direction of stable and unstable atomic and molecular movements between hierarchies, are argued to justify the application of free energy *functions of state* thermodynamics, i.e. constant temperature constant pressure states, to biospheric processes in which structures (per unit volume) tend to

evolve in a direction that will minimize the Gibbs free energy of formation for that three-dimensional molecular structure.

The central statement or premise of Gladyshev's hierarchical thermodynamic evolution principle, according to a 1997 book review of Gladyshev's 100-page book *Thermodynamic Theory of the Evolution of Life Forms* (in Russian), is that: 'under the action of the sun's thermal energy, substances which are thermodynamically stable in the early conditions of the earth are transformed into the various products of photosynthesis, those transformations being regulated by thermodynamic principles. During this process, from the resulting products only those *stable suprastructures* (e.g. human molecules) are selected which correspond to minimum states of the free energy of a biosystem.'[155] In sum, the principle of substance stability, together with the law of temporal hierarchies, argue that each subsystem of the biosphere evolves according to its thermodynamic tendency to seek a free energy minimum during each evolution cycle and that 'thermodynamics is the driving force for *any* evolution in nature.'[155]

Cessation thermodynamics

In human thermodynamics, *cessation thermodynamics* is the science of death and the study of the conservation of the essence of a person, in the post-cessation bonded structure of society, in relation to the first law of thermodynamics.[166] The inquisitive but cautious reader may be taken back by this subject. The question: 'what happens to a person when they die', however, is the one question that people want an answer to more than anything else.

In short, each person, i.e. human molecule, is defined according to the following essence or essential function:

$$Person = f(N_{xp,yn}, e^{-}, \gamma) \qquad [16.9]$$

where $N_{xp,\,yn}$ are the nuclei, i.e. bound states of protons *xp* and neutrons *yn*, having a net positive charge, that define a person, e^{-} are the electrons, particularly valence electrons, each having a negative charge that define a person, and γ are the photons that define a person. These components define the moral nature of a person. When someone dies, according to the first law of thermodynamics, these components are conserved in the form of transformed mass-energy. What is 'moral' or 'amoral', in a system of atoms and molecules, however, is a matter of debate.

As German-born American theoretical physicist Albert Einstein showed in 1905, everything in the universe, a human molecule included, is either matter or energy, quantities that are interconvertable or related via the expression $E = mc^2$. The first law of thermodynamics guarantees conservation of this mass-energy, in whatever transformation it may go through, good or bad.

In 1841, German physician and physicist Robert Mayer proved that 'energy can be neither created nor destroyed'.[167] This is the foremost and original statement of the conservation of energy.[168] In the years to follow, this principle expanded into the more rigorous and mathematical version of the first law of thermodynamics. Several version of the first law of thermodynamics are shown below:[169]

1.	Energy can be neither created nor destroyed.	**Mayer** [1841]
2.	All different kinds of physical energy in the universe are mutually convertible.	**Rankine** [1853]
3.	The quantity of force which can be brought into action in the whole of nature is unchangeable, and can neither be increased nor diminished.	**Helmholtz** [1863]
4.	The variation in energy of a system during any transformation is equal to the amount of energy that the system receives from its environment.	**Fermi** [1936]

The first law of thermodynamics states that 'energy is a conserved property. It can be neither created or destroyed; only its form can be altered from one form of energy to another.'[170] In simple terms, human molecules and the family and social structures they form are comprised of matter and energy, which can further be defined as mass and force, respectively. This set comprises a multigenerational social matrix. The first law of thermodynamics guaranties that, in this social matrix, this matter-energy quantity will be conserved, for the better or for the worse, i.e. towards future dynamic stability or away from in opposition to future dynamic stability.

To quote a colloquial example of how people, in modern times, intuitively use the variations of this law in relation to cessation, in the 2005 film *Star Wars* Episode III, written and directed by George Lucas, we find the following statement:

> "Death is a natural part of life
> one should rejoice for those who have died
> for they have *transformed* into the force."
>
> – Yoda: ***Star Wars: Episode III*** [2005]

The force, Lucas writes about here, is based on the teachings of the Native American Indian religion of the Yaqui Indians as described in Carlos Castaneda's 1974 book *Tales of Power.*[171] The primary goal of a person or warrior, according to Castaneda, is the continuation of his awareness after bodily death, i.e. to 'dart past the eagle and be free', where the *eagle*, in this sense, is the 'force which consumes the awareness of all living beings.'[172]

Lucas, in turn, blended this concept with his own life. Eleven years prior, on June 12, 1962, three days before Lucas was to graduate from high school, he was struck broadside by a speeding car and was sent rolling towards a walnut tree sixty miles per hour.[173] Fortunately, his seat belt snapped before the collision and he was flung from the car, which, a split second later, collided with such a 'force', that it moved the tree two feet, roots and all. If the seatbelt had worked, Lucas would have been killed instantly. 'You can't have that kind of experience and not feel that there is some reason why you're here,' said Lucas. 'I realized I should be spending my time trying to figure out what that reason his and trying to fulfill it.' According to author David Pollock, who interviewed Lucas in great length in preparing his biography, stemming from this incident, to Lucas, the *force* means 'looking into yourself, recognizing your greatest potential (chemical potential), visualizing the obstacles in route to that potential (activation energy and activation entropy barriers), and through effort, fulfill that most wanting objective.'[173]

In modern terms, although verbally we can still side with Lucas, we know that the force of human life, both in-life and post-life, is the *electromagnetic force*, being influenced subtly by the *gravitational force*. Moreover, although there is far more to the picture than Yoda's elegant quote, e.g. transformations mediated out of or related to deaths involving paternal suicide, sibling suicide, murder, infant death, coma-state deaths, sudden infant deaths, wrongful murder, birth-defect related child deaths, abortion, old-age deaths, extreme old age (100+) deaths, genocide, infanticide, physician assisted suicide, war related deaths, pet-bonding deaths, etc., whenever a working thermodynamic system, e.g. a system of human molecules, undergoes a *transformation* of state, which may occur due to exchange of heat, performance of work, and or change in chemical composition, there will be an associated energy change dU in the system that will depend only on the initial and final states of the transformation.[174] Said another way, when system of atoms and molecules undergoes a transformation, the change in the energy U depends only on the initial and final states, and that in a *cyclic process*, i.e. a process in which the system returns to its initial state, the integral of the energy change is zero:[174]

$$\oint dU = 0 \qquad [16.10]$$

In thermodynamic terms, a change in the 'state' of the system signifies that there has occurred a change in a *state variable*, which describes the momentary condition of a

system.[175] Examples of state variables include: energy E, Helmholtz free energy A, Gibbs free energy G, enthalpy H, internal energy U, entropy S, and temperature T.

In human reaction terms, when an individual human molecule reaches its point of termination, the energy, in quality and quantity, that defines the moral essence of a person, will affect specific state variables, such as entropy S, enthalpy H, and free energy G, conservatively, in the thermodynamic systems of the residual generations, in such a manner to satisfy the first law of thermodynamics. In simple terms, or in a colloquial sense, the science of cessation thermodynamics explains what happens to a person when they die and how those conserved energy transformations effect later generations in bonding stability.[176] Said another way, when someone dies, the energy content of that person's moral nature will transform though the family bonds, thus affecting the efficiency or free energy G work-output of subsequent generations; energy, which thus mediates out into the dynamic bonds and neuro-matrix of society, constructively or destructively, depending on the 'state of the death'.

In modern times, to elaborate on why cessation thermodynamics is a necessary and needed branch of science, the three most wanting philosophical puzzles have to do with the subjects of death, love, and life. Specifically, when random people are polled with the question:

> "What is humankind's present-day greatest philosophical conundrum?"

the following top-three responses will result:[177]

What Happens When You Die? (27%)
What is Love? (23%)
What is the Meaning of Life? (19%)

What is love, obviously relates to heightened energetic states associated with favored chemical reactions and the long-term or short-term bonding relationship dynamics mediated therefrom. What is the meaning of life, likewise, relates to the meaning or purpose related to the burning of various chemical *potentials* as people react along their life course. What happens when you die, although easily quantified via chemical thermodynamics, is a touchy subject. Not only is this query the most wanting, but no scientist, in the history of human kind, has ever come even remotely close to satisfactorily answering this perplexing question.[178]

A point to note, in discussing this rather obscure topic, from a chemistry point of view, is that the conception of there being some sort of energy conservation in the moral nature of a molecule, i.e. *soul*, *spirit*, *essence*, *p'o*, *hun*, *yin, yang, pitri, atman, nafs, ruh, kami, jiva, pheuma, physche, élan vital, fravashi, totism, psychopomp, dooh, dusha, rauch, n'shama, ka*, or *ba*, etc., in an historical sense, is an obscure or

rather nonsensical idea. That is, the idea of a hydrogen molecule H_2 in possession of a soul, for instance, is basically ridiculous. Moreover, in the big-picture scheme of a 13.7 billion-year-old universe, knowing that 'life' on earth renews through periodic 26-year extinction cycles, the idea of there being a conservation residual or post-cessation impact due to the termination essence of one person, or human molecule, at death, becomes trivial in its nature and argument.

On the other hand, within the sphere of the neuro-personal matrix of human life, the effect of immediate and distal deaths, its types, repercussions, and residual moderations are far-reaching and powerful in the manner in which those impacts and structural changes become mediated out in the framework of family life, social life, and in human society as a whole. Many people have stronger connective bonds to the deceased than to those alive. Likewise, the effects associated with world wars where millions die at a time, is one example of how death functions to transform a post-war society. To cite another strong example, it is known that children born into and raised in a family structure in which there was a parental suicide, will later in life tend to reproduce less, on average, and to operate differently in life, e.g. tend to work harder, than as compared to those raised in the utopian nuclear family. Hence, the only scientific way to explain these types of effects is through discussions of favored and disfavored energy transfers and post-cessation energy transformations, through human chemical bonds, as defined by the first law of thermodynamics.

Modern science, in general, either describes the total universe and human beings without reference to a soul, i.e. 'moral quantity', or to an afterlife; or tends to remain mute on the issue. The scientific method, generally, offers few tools for investigating these concepts. One notable exception, however, was the famous soul-weighing study conducted by American physician Duncan MacDougall. In 1901, MacDougall sought to measure the weight purportedly lost by a human body when the soul departed the body upon death.[179]

MacDougall, in his laboratory, weighed dying dogs, horses, and then patients in an attempt to prove that the soul was material, tangible and thus measurable. These early experiments are widely considered to have little scientific merit, and although MacDougall's results varied considerably, he concluded that the human soul weights 21 grams; for some people this figure has become synonymous with the measure of a soul's mass.[180] The 2003 movie *21 Grams*, starring Sean Penn, Naomi Watts, Benicio Del Toro, was based on MacDougall's findings.[181]

Other scientists, such as English molecular biologist and Nobelist Francis Crick, have attempted a 'scientific search for the soul'.[182] American mathematical physicist Frank Tipler argues that physics can explain immortality.[183] In recent years, investigations have been conduced which indicate that *out-out-of-body* experiences of death and near-death experiences are only fictions of the mind. One hospital, in order to validate various claims of out-of-body experiences placed an LED marquee above its patients' beds, which displayed a hidden message that could only be read if

one were looking down from above. To date, not one person who has claimed to have had a near-death or out-of-body experience within that hospital has expressed having seen the hidden message.[184] Likewise, in 2005, after interviewing scientists, scholars, and engineers, of what science has to say about the afterlife, journalist Mary Roach published current findings of what science has to say about death in her book *Spook – Science Tackles the Afterlife*. Most reviewers, however, find the book to be humorous, but leading to no conclusions.

In general, the majority of these views remain scattered and without foundation. The central goal of cessation thermodynamics is to unify the varieties of the world's 'religious experiences', in the words of William James, regarding the subject of cessation with that of human thermodynamics. Responses to the prospect of dying can be organized into three main categories: those who believe that somehow we shall be resurrected to pass eternity with intact bodies as the same people we were during our earthly sojourns; those who believe that what survives is a 'soul', or essence, which leaves behind forever the dead and decomposing receptacle in which it resided to move on in some fashion; and those who believe that death erases our lives entirely.[196] The current distribution of faith and non-faith beliefs in the world are listed below:[185]

Rank	Religion	%
1	Christian	32.8
2	Muslim	19.6
3	Hindu	12.8
4	Nonreligious	12.8
5	Chinese Religions	6.4
6	Buddhist	6.0
7	Ethnic Religionists	4.2
8	Atheist	2.5
9	New Religionists	1.7
10	Sikhs	0.4
11	Jews	0.2
12	Spiritists	0.2
13	Bahais	0.1
14	Confucians	0.1
15	Jains	0.07
16	Shintoists	0.05
17	Other Religionists	0.02
18	Zoroastrians	0.005
19	Mandeans	0.0006

In these religions, one can find the threads of an argument to the effect that there is a quantity of person-specific moral 'energy content', which may have both positive and negative factors, that following human point cessation, remains as conserved fixated residual human chemical bond energy, and which is later neurologically reincorporated into subsequent generations. These neurological and neurochemical reconfigurations have the resultant effective of either increasing or decreasing both a person's way of life, well-being, and or fertility.

> “It’s more like an *energy transfer*. Even though my mom has passed away, I still feel her with me, even closer if that’s possible.”
>
> – TV Show: ***Melrose Place*** [2005]

In cessation thermodynamics, a point to note is that only three particle components are involved in all discussions: photons, electrons, and nuclei. In other words, there is no hidden agenda here: humans are molecules, bonds are chemical, and death is a dissociation transformation reaction.

Lastly, to note, within the evolution framework of the earth’s 26-million-year mass extinction cycles, the basic principles of cessation thermodynamics hold. To connect this line of reasoning to solar, galactic, and universal change, however, there needs to be a more connective theory as to how the universe evolves, from the sub-atomic to the extra-galactic and beyond. In other words, one needs to explain how human molecular reaction life and reaction death relate or connect to the cycle or function of the universe.

Exodermal regeneration cycles

In biogeochemistry, an exodermal regeneration cycle is the twenty-six million year process wherein the earth molecule grows, sheds, reincorporates, and renews it 'living' integumentary system, i.e. lithosphere, hydrosphere, atmosphere, biosphere. To understand where human reaction life fits in relationship to the reaction life of the earth the ‘sloughing hypothesis’ was conceived.

The *sloughing hypothesis* is a theory in human thermodynamics that postulates that mass extinctions, which occur approximately once every twenty-six million years, varying in a cyclical manner, are the result of earth molecule integumentary system self-regulatory shedding processes wherein the earth jettisons its climax ecosystem skin through a cycle of growth and renewal by a yet unknown biogeochemical process.[186] This is analogous to how a human molecule grows and discards its epidermal and dermal layers of mammalian skin at each lunar cycle; or how a snake sheds its scale skin at each semi-yearly molt; or how the sun sheds its magnetic skin at each sun spot cycle. This earth exoderm shedding and molecular reincorporation process results functionally to drive the biosphere back to organizational ground zero enabling it to start the molecular evolutionary buildup process again so to grow a new 'living' exosphere. We define this twenty-six-million year growth and renewal process to be earth's *exodermal-regeneration cycle*.[187]

Recapitulation and Conclusion

As this textbook is one long argument, it may be convenient to the reader to have the leading facts and inferences briefly recapitulated. That many and grave objections may be advanced against the theory of human chemistry with modification or chemical reaction thought natural energetic selection, we do not deny, we have endeavored to give them their full force.

Nothing at first can appear more difficult to believe than that the more complex organisms and instincts should have been perfected, not by means superior, though analogous with, human reason, but by the accumulation of innumerable slight chemical reactions, exchanges, and variations, each good for the individual possessor. Nevertheless, this difficultly, though appearing to our imagination insuperably great, cannot be considered real if we admit to the following propositions, namely, first that gradations in the perfections of any organism or instinct, which we may consider, follow a change of thermodynamic state from one course to the next, being characterized or actuated upon via of constraints imposed according to a thermodynamic system-surroundings microcosm, second that this change of state evolves temporally and irreversibly towards inherent constant-pressure, constant-temperature system-characterized minimum energy wells, third that the qualitative and quantitative kinetic mechanisms underwriting these change of states actuate solely according to outer-shell, electron-photon, quantum electrodynamic interactions, i.e. heat movements, which in sum accounts for the predominance of all earth-bound activity, and fourth that the human organism, as well as any variation of molecular structure, ascribe irreducibly to the laws of the hard sciences. The truth of these propositions cannot, we should suppose, be disputed.[188]

What is life?

To a good approximation, as discussed, one of the most oft-quoted references in thermodynamics is Erwin Schrödinger's 1944 postulate that an organism keeps itself alive or aloof by feeding on negative entropy from its environment.[189] From the famous chapter six 'Order, Disorder and Entropy' of his book *What is Life?*, Schrödinger asks 'what is the characteristic feature of life? and 'when is a piece of matter said to be alive?'[190] To answer these questions, Schrödinger turns to thermodynamics.[191] Life, according to Schrödinger, avoids a decay to maximum entropy, or thermodynamic equilibrium, which Schrödinger equates with death, by feeding on negative entropy. Specifically, according to Schrödinger, an organism avoids decay by eating, drinking, breathing, and in the case of plants assimilating, a process called metabolism.

In the past, Schrödinger states, this process would have been considered an exchange of matter or energy, such that organisms stay alive by exchanging energy.

He uses the example of how caloric values are printed in certain menus in the United States or Germany, but states that these caloric energy exchange values are useless in trying to quantify life. He then asks 'what then is that precious something contained in our food which keeps us from death?' The answer, according to Schrödinger, is that because according the second law of thermodynamics an organism continually produces 'positive entropy' it must continually draw in 'negative entropy' from its environment to stay alive. Or, specifically, 'the essential thing in metabolism is that the organism succeeds in freeing itself from all the entropy it cannot help producing while alive.'[192]

These suppositions, because they were intended for a lay audience, however, met with great opposition in the physics community. In later editions of his book, Schrödinger attached a note to chapter six explaining his use of the term negative entropy'. He states:[193]

> The remarks on *negative entropy* have met with doubt and opposition from physicist colleagues. Let me say first, that if I had been catering for them alone I should have let the discussion turn on **free energy** instead. It is the more familiar notion in this context. But this highly technical term seemed too linguistically near to *energy* for making the average reader alive to the contrast between the two things.

In conclusion and summary of his classic 1944 booklet, Schrödinger argues that, despite our 'obvious inability' to define it, *life* would eventually be accounted for by physics and chemistry. The year is now 2007. Sixty-three years have passed since this excellent hypothesis was made. Herein, in Schrödinger's own words, we have 'let the discussion turn on *free energy*', the great conception of Gibbs.

> (Gibbs) the greatest thermodynamicist of them all.
> – John B. Fenn, *Nobel Prize in Chemistry*, 2002[194]

To summarize this quick introduction to the new science of human chemistry, the reader is encouraged to take away two points: (1) the human organism is a 26-element molecule; (2) there are two competing tendencies effecting the reaction life of this molecule: energy and entropy. Energy tends to force a system into one single state, and entropy tends to spread the system evenly over all possible states. These competing tendencies are weighed by temperature such that minimal energy determines cold systems.[195]

Postscript

To clarify a few loose ends, first, we apologize to the astute reader as to the matter of the incomplete and crude nature of this book.[189] This book is an approximate first draft on a basic topic having been nearly untouched, i.e. not since American navel engineer William Fairburn's tiny, 55-page, booklet *Human Chemistry*, has someone written a book on human chemistry. Hopefully, this textbook was a step up from the former. Second, we mention that the topic of human chemistry is not the author's primary interest, which is the thermodynamics associated with human chemistry, a more advanced topic.

This short book, subsequently, was written out of necessity. In any standard chemistry textbook, the chapters on thermodynamics are usually are found in the latter half of the book. As such, it is difficult to discuss or theorize on the topic of *human thermodynamics*, i.e. heat movements in human life and the work generated therein, until the basic topic of *human chemistry*, i.e. the chemistry of human life processes, is established as a core branch of science.

Contact author

Thank you for taking the time to read this book. To help in the improvement of a possible second edition, please contact the author directly at the following address, with comments, suggestions, criticism, grammatical errors, theoretical issues, typos, ideas, disagreements, or any other concerns:

Email: humanchemistry@sbcglobal.net

Owing to time restrictions, to note, the first edition published swiftly in unpolished format; hence, any helpful comments or constructive criticism would be appreciated.

References and Notes:

"If I have seen further it is by standing
on ye shoulders of Giants."

Isaac Newton, English physicist

Note: (a) Note 1: all humanthermodynamics.com and humanchemistry.net articles and pages, unless otherwise indicated, e.g. as in the *Journal of Human Thermodynamics*, were written by Libb Thims.
(b) Note2: in 2005 through 2007, the author started, wrote, or significantly contributed to 164 articles in Wikipedia, some material of which was tested for likeability and stability before inclusion here:
[URL]: http://en.wikipedia.org/wiki/User:Sadi_Carnot/Contributions
(c) Note3: we would like acknowledge those tireless Wikipedians who were involved in the editing and construction of these articles with Thims.

Back Cover: (a) Quote Schopenhauer: (Article) *Sex and Schopenhauer.*
[URL]: http://flatrock.org.nz/topics/society_culture/sex_and_schopenhauer.htm
(b) Quote Garbo: (Article) "*The Right Chemistry" Time Magazine, Feb. 15, 1993.*
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Praise For: [1] John Scales (Wikipedia); [URL]: http://en.wikipedia.org/wiki/John_Avery_Scales
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(b) Iodine and evolution [URL]: http://www.iodine4health.com/special/venturi_evolution.htm
[4] (a) Minkin, Viktor. (2007). Confounder of the Russian Elsys Corporation.
(b) Elsys Corporation (Website); [URL]: http://www.elsys.ru/index_e.php
(d) Dermatoglyphics (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Dermatoglyphics
[5] See also: "IoHT List of 30+ Praises & Criticisms"
[URL]: http://www.humanthermodynamics.com/Testimonials.html

10 – Goethe's Affinities: [1] Hollingdale, R. J. (1971). *Introductory Comments* in Penguin Classics' 1971 Translation of Goethe's 1809 *Elective Affinities.* New York: Penguin Books.
[2] Putti Image as found on the title page of: P. J. Macquer's *Elemens* (2nd ed, 1753).
[3] Levere, Trevor, H. (2001). *Transforming Matter – A History of Chemistry from Alchemy to the Buckyball*. Baltimore: The Johns Hopkins University Press.
[4] Goethe, Johann Wolfgang von (1999). *Elective Affinities – A Novel (translated with an Introduction and Notes by David Constantine)*. Oxford University Press.
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[6] Smith, Peter, D. (2001). *Elective Affinities* (online). Abstract from the article that appears in Prometheus 04. [URL]: http://www.prometheus.demon.co.uk/04/04smith.htm
[7] Ellis Dye, Macalester College. "Die Wahlverwandtschaften [Elective Affinities]." *The Literary Encyclopedia*. 5 Dec. 2005. The Literary Dictionary Company. 13 March 2007.
[URL]: http://www.litencyc.com/php/printer_format_works.php?UID=5600
[8] (a) Note: Goethe's statement that he wrote *Elective Affinities* for 'young girls' (as reported by Varnhagen von Ense, pg. 321), is one of the many cryptic comments made by Goethe. It is highly likely, according to Thims' point of view, that Goethe wrote *Elective Affinities*, for young girls, as he says, for the same reason that *Human Chemistry* (a modern day *Elective Affinities*) was written, i.e. 'for a young person 7-15 years of age'; namely that in Goethe's time, as is the case presently, no one teaches a young person how the world really is. Moreover, past a certain age, people, on average, will no longer be malleable to correct teachings. As such, Goethe invariably wrote *Elective Affinities* so that young, un-biased, girls (persons) might know how the world really is, namely a chemical one.
(b) Note: the 'little girls' comment comes after a stream of criticism following the publication of his novella, where many called it reprehensible; thus, when his old friend Knebel started making moral objections to the novel Goethe exploded: 'But I didn't write it for you, I wrote it for little girls!' R.J. Hollingdale, translator of the 1971 Penguin Classics English edition, reasons that Goethe made this statement 'to assert that the book is altogether wholesome and romantic and that only a moralizing old man could find anything in it to object to' (pg. 14).
(c) To his fellow author and neighbor Christoph Martin Wieland, Goethe indicated that the novel had to be read at least three times before it could be understood (source: Tantillo).
(d) Nearly twenty years after its publication, Goethe stressed to his friend Johann Peter Eckermann that the novel could never be comprehended in a single reading of it (source: Tantillo).
(e) On June 01, 1809, Goethe wrote to his friend, the composer Karl Friedrich Zelter, that he not only placed numerous different elements within the text, but that many of these were hidden with in it and that past the transparent or non-transparent veils in the novel one may be able to see the 'truly intended *Gestalt*' (source: Tantillo).
(f) Tantillo, Astrida O. (2001). Goethe's *Elective Affinities* and the Critics. (pg. xx). New York: Camden House.
(g) Varnhagen von Ense, Kaarl August. Diary Entry. 28 June 1843, Quoted here from *Karl August Varnhagen von Ense Werke.* 5 vols. Frankfurt: Keutscher Kalssiker verlag, 1994. 5:320-21. Also reprinted in: *Goethes Werke*. Ed. erich Trunz. 14 vols. Hamburg: Christian Wenger Verlag, 1949-71. Reissued 13th Ed., Munich: Verlag C. H. Beck., 6:641.
[9] (a) Smith, Peter, D. (2001). *Elective Affinities* (online). Abstract from the article that appears in Prometheus 04. [URL]: http://www.prometheus.demon.co.uk/04/04smith.htm
(b) Tantillo, Astrida O. (2001). Goethe's *Elective Affinities* and the Critics. New York: Camden House.
[10] (a) Goethe's accomplishments include being a: lawyer, novelist, playwright, poet, humanist, dramatist, painter, mayor, natural philosopher, scientist, and polymath to name a few.
(b) Johann Wolfgang von Goethe (Wikipedia);
[URL]: http://en.wikipedia.org/wiki/Johann_Wolfgang_von_Goethe
(c) Johann Wolfgang von Goethe (Columbia Encyclopedia);
[URL]: http://www.bartleby.com/65/go/Goethe-J.html
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(b) Mimkeys, J. (2003). "Concepts of Thermodynamics in Economic Systems." I. Economic Growth, Physics Department, University of Paderborn, Germany.
[PDF]: http://www.rrojasdatabank.info/thermo/econom1.pdf
[23] See: chapters 6-9.
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(b) For a discussion of other tables see: A. M. Duncan, 'Some Theoretical Aspects of Eighteenth-century Table of Affinity', *Annals of Science*, 18, pgs. 177-94 and 217-32.
[40] *Note:* Gibbs did not himself make thermodynamic tables, per se, but rather only derived the theory and formulae for others to use to in later years to make thermodynamic tables. The first to begin doing this was Fritz Haber in his 1905 book *Thermodynamics of Technical Gas Phase Reactions*, in which he was the first to systematically study all of the thermodynamic data necessary for the calculation of free energy changes in chemical reactions. Gilbert Lewis and Merle Randall spent many decades constructing free energy tables as are found in their 1923 *Thermodynamics and the Free Energy of Chemical Substances.* The first thermodynamic table of biochemical species was published by K. Burton in 1957.
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[43] Goethe's *Elective Affinities*, part II, chapter 17.

[44] Plummer, Andrew. (1771). *Essays and Observations Physical and Literary*, vol. ii, Edinburg, 2nd Edition, pgs. 381-3.
[45] Anon [J. P. Macquer], *Dictionnaire de Chymie*, Paris, 1766, vol. I, pgs. 49-50.
[46] That free energy is the true measure of affinity, was a fact proved by Hermann von Helmholtz in 1882.
[47] J. L. L. de Buffon, (1765). *Histoire Naturelle*, Tome xiii, 'Second Vue de la Nature', Paris, pgs. xii-xvi.
[48] Michelle Goupil, *Du Flou au Clair?,* 139-146; idem, "J. Ph. de Limbourg et la theorie des affinities chimiques," *Technologia 7*, 1984, 11-28; James Evans, "Gravity in the Century of Light: Sources, Construction and Reception of Le Sage's Theory of Gravitation," *Pushing Gravity*, ed. M. Edwards (Apeiron, 2002).
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(b) A recent two-year study of 6,318 American women, conducted by the North Carolina State University, found that 8.4% were hourglass-shaped, 20.92 were spoon-shaped, 46,12% were rectangle-shaped, and that 13.83% were triangle-shaped.
(c) McCormack, Helen. (2005). "The shape of things to wear: scientists identify how women's figures have changed in 50 years", *The Independent.* 21 November
[URL]: http://news.independent.co.uk/uk/this_britain/article328328.ece
[52] Tantillo, Astrida, O. (2001). *Goethe's Elective Affinities and the Critics*. New York: Camden House.
[53] (a) To clarify, the human molecule is no greater or lesser a molecule than any other molecule, surrounding a heat source (such as burning star), in the universe. A molecule is a molecule.
(b) Said another way, each human is no more or less greater than any other molecular body on the surface of the earth; in the universe, however, one might argue that molecules on those planets positioned close to medium sized stars that are 1/3 of the way through their life-cycle, e.g. the sun is about 5 billion years old in a 15 billion year life-cycle, may have a sort of dynamic kinship to human molecules. A way quick way to quantify this is to use distance to diameter ratios. The sun, for example, has mean diameter of 1.39x10E6 km and the mean distance between the sun and the earth is 149x10E6, hence distance to diameter ratio is 107. Thus, molecules found at a D-to-D ratio of 107 about heat releasing stars that are 1/3 in age, may have properties similar to human molecules.
[54] Technically, [10.4] would require the use of a more advanced reaction mechanism with more intermediates to give an accurate mass balance. When calcium sulfide, which is normally a white crystalline solid, dissolves in water, for example, it yields a mixture of three species: $Ca(SH)_2$, $Ca(OH)_2$, and $Ca(SH)(OH)$. Likewise, when sulfuric acid is mixed with water it will yield two species: HSO_4^- and SO_4^{2-}. Subsequently, several reactions would be required to explain the full mechanism this process. These, however, are only technicalities, being that, in Goethe's time, the idea of reaction intermediates was not yet an established concept; thus, Bergman's diagrams capture the main points of the reaction.
[55] (a) An example of this is Tom Stoppard's 1993 play *Arcadia*, a modern-day *Elective Affinities*, in which the second law is utilized as well as Newton's affinities and other theories; although, to note, the free energy function *G* is not used in specifically, only indirectly.
(b) Stoppard, Tom. (1993). *Arcadia.* New York: Faber and Faber, Inc.
(c) The 2005 book-in-progress *Entropy and Human Values* by Dimitris Keranis gives a sociological take on Gibbs free energy and nature's tendency to organize itself through the production of work.
[URL]: http://www.entropy-and-humanvalues.gr/english.htm
[56] Demachy, Jacques. (1781) *Recueil de Dissertations Physico-Chimiques Presentes a Differentes Academies*.
[57] Lavoisier's *Elements of Chemistry*, pg. 57.
[58] Lavoisier's *Elements of Chemistry*, pg. 125-26.
[59] Lavoisier's *Elements of Chemistry*, pg. 212-290.
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[63] Goethe, J. (1796). *Lectures on Anatomy*, I, 9, pg. 202f.
[64] In a conversation with Riemer dated July 24, 1809, Goethe names Bergman as the source for the idea of 'elective affinity'. See: Romanticism and the Sciences.
[65] (a) To understand that human molecules have no choice in their own affairs, please review chapter five, i.e. molecular evolution, showing the linearity of molecular evolution table, e.g. the growth of hydrogen molecules to human molecules, to see the inconsistency in this type of this argument.
(b) In any standard chemistry, biochemistry, or neurochemistry textbook, one will not find the word "choice" in the index; there is, however, quantum electromagnetic mechanism of choice. In short, preceding each conscious choice, there will be a measurable amount of electromagnetic mental activity, in the form of a thought potential, several microseconds prior to the action of the choice. These are, in effect, neurochemical and neuro voltage potentials changing or reconfiguring in the direction of the choice, which are themselves dependent on the state of individual as well as past sensory inputs and past neurological growth developments, and other factors.
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(c) H. B. Nisbet, (1969). '*Die Wahlverwandtschaften*: Explanation and its Limits', *Deutsche Viertejahrsschrift fur Literaturwissenschaft and Geistesgeschichte*, 43, 458-86;
(d) E. L Stahl, (1945). '*Die Wahlverwandtschaften'*, Publications of the English Goethe Society, new series, 15, 71-95;
(e) F. J. Stopp, (1959-60). 'Einwahrer narziss: Reflections on the Eduard-Ottilie Relations in Goethe's *Wahlverwandtschaften*', *Publications of the English Goethe Society*, new series, 52-85;
(f) Waltraud Wietholter, (1973). 'Legenden. Zur Mythologie von Goethe's *Wahlverwandtschaften*', *Deutsche Viedrteljahrsschrift fur Literaturwissenschaft und Geistesgeschichte*, 56, 1-64.
[77] (a) J. B. Trommsdorff's (1805-15). *Systematisches Handbuch dre gesammeten Chemie*. I, pg. 51f.
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(c) Dunbar, R.I.M. (1993), *Coevolution of neocortical size, group size and language in humans*, Behavioral and Brain Sciences 16 (4): 681-735.
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[87] Examples include: (a) *Sexism* – namely discrimination, prejudices, and or hatred against people based on their sex rather than their individual merits
Sexism (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Sexism
(b) *Racism* – namely discrimination, prejudices, or hatred based on a belief or ideology that all members of each race possess characteristics or abilities specific to that race, especially to distinguish it as being either superior or inferior to another race or races.
Racism (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Racism
(c) Sunni-Shiite inter-religion tensions (Iraq war 2007).
(d) Rwanda genocides involving the Hutu and Tutsi ethnic groups in 1994.
(e) *Caste systems* – which are traditional, hereditary systems of social restriction and social stratification, enforced by law or common practice, based on endogamy, occupation, economic status, race, ethnicity, etc; Caste (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Caste
(f) *The Holocaust* – an event where approximately 6 million European Jews were killed along with ½ million half a million Sinti and Roma, as well as the disabled, homosexuals, Jehovah's Witnesses, Soviet POWs, Polish citizens, and political prisoners; [URL]: http://en.wikipedia.org/wiki/Holocaust
(g) Intercultural differences, such shown in the 2004 film Crash, which depicts modern-day racial and social tensions in Los Angeles; Crash (2004 film) (Wikipedia);
[URL]: http://en.wikipedia.org/wiki/Crash_%282004_film%29
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[103] Goethe's *Elective Affinities*, pg 37.
[104] Affinity of decomposition (definition), according to French chemist Antoine Baumé, source: Kim's *Affinity, That Elusive Dream*. Fact: Baumé, interestingly, was apprenticed to the Claude Joseph Geoffroy, the brother of Étienne-François Geoffroy, the two often argued about certain in Étienne's affinity table.
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[107] Goethe's *Elective Affinities*, pg 40f.
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$$S = S_{tran} + S_{rot} + S_{vib} + S_{elec}$$

where trans = translational entropy, rot = rotational entropy, vib = vibrational entropy, and elec = electronic entropy. Thus, we can be fairly confident with the summation form of human molecular

entropy, but that finding a conceptual reference point will be difficult. Third, current enthalpy changes ΔH are typically calculated via bomb a calorimetry measurement, which means that species are burned with oxygen in a combustion reaction, and the heat released is correlated with enthalpy changes.[3] It is also assumed that individual species cannot be assigned with a single instantaneous values of enthalpy H. In human life, estimates of his value would be possible, but in the chemical literature this has never been done. Fourth, the unceasing and coupled nature of earth reaction life complicates the matter further. Fifth, external reaction forces X_K is another conceptual difficulty.
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[URL]: http://en.wikipedia.org/wiki/A_Dynamical_Theory_of_the_Electromagnetic_Field
(e) Maxwell's equations (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Maxwell%27s_Equations
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(g) Kaufmann, William, J. (1994). *Universe, 4th ed.* New York: W.H. Freeman & Co. (pg. 74)
[29] (a) Veltman, Martinus. (2003). *Facts and Mysteries in Elementary Particle Physics.* New Jersey: World Scientific.
(b) On shell and off shell (Wikipedia); [URL]: http://en.wikipedia.org/wiki/On_shell_and_off_shell
[30] (a) Quantum electrodynamics (Wikipedia);
[URL]: http://en.wikipedia.org/wiki/Quantum_electrodynamics
(b) Feynman diagram (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Feynman_diagram
[31] Veltman, M. (2003). *Fact and Mysteries in Elementary Particle Physics*. New Jersey: World Scientific.
[32] Veltman (2003), ibid, pg. 71.
[33] Feynman, Richard, P. (1985). *QED – the Strange Theory of Light and Matter.* Princeton, New Jersey: Princeton University Press.
[34] The Feynman Lectures on Physics (Wikipedia);
[URL]: http://en.wikipedia.org/wiki/The_Feynman_Lectures_on_Physics
[35] Numbers shown are Amazon.com sales ranks on 05/12/07.
[36] Zero-Point Energy and Zero-Point Field (Cal-physics Institute);
[URL]: http://www.calphysics.org/zpe.html
[37] Laidler, Keith, J. (2001). *The World of Physical Chemistry*. Oxford University Press.
[38] Vacuum state (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Vacuum_state
[39] Zero-point field (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Zero-point_field
[40] Source: Linas (PhD in theoretical physics from SUNY at Stony Brook; thesis topic suggested by A. D. Jackson and Fred Goldhaber, on the bag model, which combines quark and meson models of the nucleon); Comment: "It's a peculiar term, not widely used, but roughly it is the empty quantum field, of which the quantized electromagnetic field would be an example" (made on April 29, 2006).
[41] (a) Note: the source for her definition of 'force' is Merriam-Webster.
(b) Fred Alan Wolf, *Taking the Quantum Leap: the New Physics for Nonscientists,* 1989.
(c) Masaru Emoto, *The Hidden Messages in Water,* 2004
(d) David Hawkins, *Power vs. Force: the Hidden Determinants,* 2002.
[42] (a) Quantum Ties Inc., "Our Services' [URL]: http://www.quantumties.com/services/index.html
(b) Anderson, Brenda. (2006). *Playing the Quantum Field – How Changing Your Choices Can Change Your Life.* Navato, California: New World Library.
[43] (a) Ken Wilber is an American author known for his writings that attempt to blend mysticism and science.
(b) Ken Wilber (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Ken_Wilber
(c) David Bohm is an American-born quantum physicist known for his 'holonomic brain model' and for his bridging of science, philosophy, and cognition.
(d) David Bohm (Wikipedia); [URL]: http://en.wikipedia.org/wiki/David_Bohm
(e) In the holonomic brain model, developed in collaboration with Stanford neuroscientist Karl Pribram, Bohm helped establish the foundation for Pribram's theory that the brain operates in a manner similar to a hologram, in accordance with quantum mathematical principles and the characteristics of wave patterns.
(f) Holonomic brain model (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Holonomic_brain_theory
[44] Rupert Sheldrake (Homepage); [URL]: http://www.sheldrake.org/homepage.html
[45] Morphogenic field (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Morphogenic_field
[46] (a) L'Imposture Scientifique en Dix Lecons, "Pseudoscience in Ten Lessons.", By Michel de Pracontal. Editions La Decouverte, Paris, 2001.

(b) (24 Sep 1981) "A book for burning?". *Nature* 293 (5830): 245-246. Attributed to *Nature's* senior editor, John Maddox (commenting on Sheldrake's book *A New Science of Life* (1981)), Maddox wrote: "Sheldrake's argument is an exercise in pseudo-science. — Many readers will be left with the impression that Sheldrake has succeeded in finding a place for magic within scientific discussion — and this, indeed, may have been a part of the objective of writing such a book."
[47] Holonomic brain theory (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Holonomic_brain_theory
[48] Holography (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Holography
[49] (a) Note1: Michael Talbot's 1991 book *The Holographic Universe* (#2,098 Amazon sales rank @ 05/14/07) has been the main popularizer of the 'holonomic brain model'.
(b) Note2: A full discussion of the pros and cons of this theory would carry us into a lengthy side-path. In short, the circuitry of the brain does behave similar to the circuitry of basic electrical components, which can send, receive, and process electromagnetic signals; compare, for example, Haines' 1997 textbook *Fundamental Neuroscience* with Philips and Parr's 1995 textbook *Signals, Systems, and Transforms* or with Proakis and Manolakis' 1996 textbook *Digital Signal Processing.* Hence, in theory, one could use 'transforms', which are any of various tools, e.g. Laplace transform, Fourier transform, etc., that will mathematically transform an analog wave form (such as a satellite wave, radio wave, or brain wave, all of which are electromagnetic waves) into trigonometric functions, which can then be studied from a mathematical point of view, so as to study and model the relationship between the three-dimensional (holographic) structure of brain-waves associated with individual axons and dendrites (neuro-wires) and the processes of the brain. Most automatic control system processors, e.g. those on the space shuttle, use transforms in the calculation of their regulations; see, for example, Kuo's 1995 textbook *Automatic Control Systems.* Most anthropomorphic-biased scientists, however, fluff-up and basically misconstrue this rigorous potential with nonsensical statements, such as Fred Wolf's back-cover summary comment of Talbot's *The Holographic Universe*, i.e. "the concept of the universe as a giant hologram containing both matter and consciousness as a single field will, I am sure, excite anyone who has asked the question, 'What is reality?' This book may answer that question once and for all." Statements such as this are clearly made by people that have lost track of the basic meaning of science, which is to explain things for what they are, not what one thinks they should be.
[50] Comments found in the foreword to the 2003 book *The Connectivity Hypothesis – Foundations of an Integral Science of Quantum, Cosmos, Life, and Consciousness,* by Ervin Laszlo and Ralph H. Abraham.
[51] Vitalism (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Vitalism
[52] (a) Remote viewing (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Remote_viewing
(b) Trivia: in the 2004 thriller Suspect Zero detectives must track a killer who has the remote viewing ability.
(c) Holonomic brain model (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Holonomic_brain_theory
(d) Sheldrake, Rupert. (2000). *Dogs that Know When Their Owners are Coming Home – and Other Unexplained Powers of Animals.* Three Rivers Press.
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[54] Gribbin, John. (2002). *Quantum Physics – a Beginner's Guide to the Subatomic World.* London: DK Publishing.
[55] Schummerr J (2003) The notion of nature in chemistry. *Stud Hist Phil Sci* 34:705-736 for this account within an extensive review on vitalist notions in the foundations of chemistry.
[URL]: http://www.joachimschummer.net/papers/2003_NatureChemistry_SHPS.pdf
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From Friedrich Wöhler to Hans A. Krebs", *American Journal of Nephrology*;19:290-294.
[57] Hesse, Mary, B. (1962). *Forces and Fields – the Concept of Action at a Distance in the History of Physics.* New York: Dover Reprint.
[58] Michael Faraday Biography (World of Physics);
[URL]: http://www.bookrags.com/biography/michael-faraday-wop/
[59] (a) Maxwell, James, C. (1861). "On the Physical Lines of Force" (62pgs) *Philosophical Magazine and Journal of Science,* March; [PDF]: http://vacuum-physics.com/Maxwell/maxwell_oplf.pdf
(b) Thomson, William (1847). "Mechanical Representation of Electric, Magnetic, and Galvanic Forces," Cambridge and Dublin: *Mathematical Journal,* January.
[60] (a) Maxwell, James. (1873). *A Treatise on Electricity and Magnetism.* New York: Dover Reprints.

(b) A Treatise on Electricity and Magnetism (Wikipedia);
[URL]: http://en.wikipedia.org/wiki/Treatise_on_Electricity_and_Magnetism
[61] Electromagnetic force (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Electromagnetic_force
[62] Name of 4th century book: *Devil Valley Master* (鬼谷子); Source: Li Shu-hua, "Origine de la Boussole 11. Aimant et Boussole," *Isis*, Vol. 45, No. 2. (Jul., 1954), p.175.
[63] De Magnete (Wikipedia); [URL]: http://en.wikipedia.org/wiki/De_Magnete
[64] Note: the word *electric* was first used in 1646 Eng. by Eng. physician Sir Thomas Browne (1605-1682), coined in Mod.L. by Eng. physicist William Gilbert (1540-1603) in treatise *"De Magnete"* (1600), from L. *electrum* "amber," from Gk. *elektron* "amber" (Homer, Hesiod, Herodotus); Source: Online Etymology Dictionary.
[65] (a) Note: The ancient Greeks were aware of the ability of loadstone to attract small pieces of iron. The Greek word *magnes*, which is the root of the English word magnet, is thought to be derived from Magnesia, the name of an ancient city in Asia Minor, which, presumably, was once a copious source of loadstones; source: [URL]: http://farside.ph.utexas.edu/teaching/302l/lectures/node54.html
(b) Related fact: the *Magnetes* were an ancient Greek tribe living in Thessalian Magnesia who took part in the Trojan War. They later also contributed to the Greek colonization.
Magnetes (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Magnetes
Thessaly (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Thessaly
Magnensia (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Magnesia
[66] Mahon, Basil. (2003). *The Man Who Changed Everything – the Life and Science of James Clerk Maxwell.* UK: John Wiley & Sons.
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[68] Daintith, John. (2005). *Oxford Dictionary of Science.* Oxford: Oxford University Press.
[69] (a) Daintith, John. (2005). *Oxford Dictionary of Science.* Oxford: Oxford University Press.
(b) Maxwell's equations (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Maxwell%27s_equations
(c) Divergence operator (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Divergence
(d) Curl operator; (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Curl
(e) Electric displacement (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Electric_displacement_field
(f) Electric field strength (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Electric_field
(g) Magnetic field strength (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Magnetic_field
(h) Volume charge density (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Electric_charge
(i) Electric current density (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Current_density
[70] Sheldrake, Rupert. (2003). *The Sense of Being Stared At – and Other Unexplained Powers of the Mind.* New York: Three Rivers Press.
[71] Article (retrieved: May, 2007), "Seizure dogs – and How do They Detect Seizures?" *Central Florida Epilepsy Foundation.* [URL]: http://www.epilepsy-cf.org/seizure_dogs.htm
[72] Electroencephalography (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Electroencephalography
[73] See: chapter seven for discussions on "primary" vs. "secondary" field particles.
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[75] Exchange force (Wikipedia) [URL]: http://en.wikipedia.org/wiki/Exchange_force
[76] (a) Thims, Libb. (2006). "Query: Is there such a thing as a *human chemical bond* between humans?", June, *Yahoo! Answers*, [N=8 theories as to why the answer is yes].
[URL]: http://answers.yahoo.com/my/my;_ylt=AujiMNZTa8mBWsBhDUBR53Xsy6IX
(b) Miller, Warren, B. & Rodgers, Joseph, L. (2001). *The Ontogeny of Human Bonding Systems – Evolutionary Origins, Neural Bases, and Psychological Manifestations.*
(c) Chemistry Department. (2002). "Its all about Bonding": How Humans, Animals, Chemicals, and Natural Forces, have Conflicted in Time, but Also Worked Together.
(d) Research Outline Plan [PDF]:
http://www.nths.newtrier.k12.il.us/academics/faculty/gressel/mendelevwebquest/webquesthandout.pdf
(e) Homework Website:
[URL]: http://nths.newtrier.k12.il.us/academics/faculty/gressel/mendelevwebquest/process.htm
[77] (a) *Human chemical bond:* A '07 *Google* book-content search shows no definitions; a '07 *Amazon* book-content search shows no hits; a straight Google search shows that Libb Thims' 2005 JHT article "On the Nature of the Human Chemical Bond" is the only publication using this term.

[URL]: http://www.humanthermodynamics.com/JHT/Human-Chemical-Bond.html
(b) According to meta-analysis by the author no one has defined this term; loosely related terms are the "limbic bond", "pheromone bonds", Goethe's chemical affinity ties, etc.
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(b) Vitalism (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Vitalism
(c) Odic force (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Odic_force
(d) Élan vital (Wikipedia); [URL]: http://en.wikipedia.org/wiki/%C3%89lan_vital
(e) Animal magnetism (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Animal_magnetism
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[URL]: http://en.wikipedia.org/wiki/The_Secret_%282006_film%29
[85] (a) Whittaker, S. (2007). "Secret attraction", *The Montreal Gazette*, May 12th.
(b) Adler, Jerry. (2007). "The Secret:" Does Self-help book Really Help?, *Newsweek*, March 5.
[URL]: http://www.msnbc.msn.com/id/17314883/site/newsweek/
(c) Note: Being misinformed about what the secret actually is, namely Plato's first law of affinity, which in modern terms has been replaced by the laws of thermodynamics, quantum chemistry, and quantum electrodynamics, exuberantly told her audience "she'd been living her whole life according to the law of attraction, without even knowing it." (Oprah ran two segments, the first on Feb 8, 2007).
[86] Amazon.com sales rank (#4) of *The Secret* by Rhonda Byrne @ 05/14/07.
Amazon.com sales rank (#8) of *The Secret* by Rhonda Byrne @ 05/22/07.
[87] Reviewer N.Van Buskirk states that: "I was presented this DVD at work and I found it disturbing. A gimmick to say the least, but the real issue is that I felt like I was being indoctrinated into a cult -- I had to leave about half-way through."
[88] (a) See: chapter nine
(b) Also, as an example, we know that attraction and repulsion similarities will cause molecules to aggregate into social formations as well as cause phase separations.
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[94] (a) See: chapter six

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(b) Games People Play (book) (Wikipedia);
[URL]: http://en.wikipedia.org/wiki/Games_People_Play_%28book%29
[96] Note: based on Freud's thermodynamic concept of the human psyche as composed of the id, ego, and super-ego, Berne postulated instead three "ego states", i.e. the Parent, Adult and Child states that are largely shaped through childhood experiences.
[97] Allen, James, R. (2004). A "New Introduction" commentary section as found in the 2004 publication of Berne's book *Games People Play*.
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[URL]: http://en.wikipedia.org/wiki/Computational_chemistry
(b) Supramolecular chemistry (Wikipedia);
[URL]: http://en.wikipedia.org/wiki/Supramolecular_chemistry
(c) Nanochemistry (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Nanochemistry
[99] Carroll, Robert. T. (2003). *The Skeptic's Dictionary* (The Full Moon and Lunar Effects), Wiley.
[URL]: http://skepdic.com/fullmoon.html
[100] (a) Lieber, Arnold. L. (1996). *How the Moon Affects You.* New York: Hastings House.
(b) An article in UK's *Independent* rounded up over 50 research papers that studied the effect of the moon on human behavior and concluded that, for reasons entirely inexplicable, the phases of the moon do indeed wield an influence over us. Among the findings are these stats: Visits to doctors go up by 3.6 percent during a full moon; gout and asthma attacks peak during new and full moons; the birthrate climbs every 29.53 days (the length of the lunar cycle) with human fertility peaking in the week before a full moon; aggravated assaults and other crime rates rise around the period of a full moon; car accidents are lowest on a full-moon day but rise during the waxing and waning periods
(c) Ohrt, Andreas. (2007). **"**Your Own Sci-Fi Horror Flick • Blame the Moon • Why Die Normal • And More..." *Boise Weekly,* March 28,
[URL]: http://www.boiseweekly.com/gyrobase/Content?oid=oid%3A218173
[101] (a) During the day, light blocks norepinephrine release, inhibiting melatonin synthesis and increasing the level of serotonin. Measures of carotid artery serotonin levels confirm this.
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[102] Perper, Timothy, (1985). *Sex Signals – the Biology of Love.* Philadelphia: iSi Press.
[103] Astrology correlations began with the ancient Chaldeans and Assyrians engaged in astrological divination some 3,000 years ago. By 450 BC the Babylonians had developed the 12-sign zodiac, but it was the Greeks, from the time of Alexander the Great to their conquest by the Romans, who provided most of the fundamental elements of modern astrology. Source: *The Skeptic's Dictionary*.
[104] Young, English. (2005). "What's Your Sign? – Modern astrology can give you advice on dating or help explain your personality." *The Shorthorn Staff,* March 29.
[URL]: http://www.theshorthorn.com/archive/2005/spring/05-mar-29/sc032905-01.html
[105] Carl Jung, who studied such topics as astrology, Tarot cards, etc., to identify their archetypal content, asks, 'why does that person believe in astrology and not in some other un-provable theory like a flat earth?' A belief in astrology is fulfilling some need for that person. Jung was interested in identifying those needs and classifying them under the name of archetypes.
[106] Data: Wordnet 3.0 defines *astrology* as pseudoscience claiming divination by the positions of the planets and sun and moon; [URL]: http://wordnet.princeton.edu/
[107] MSN "AstroLove" Compatibility Reports [URL]: http://www.astrocenter.com/msn/HPAstroLove.aspx
[108] (a) In chemistry labs, by comparison, gravitational effects related to reactions are usually discounted as a negligible factor if at all any factor.
(b) In 2004, Thims conducted a small study in which he used the listings of celebrity signs, i.e. celebrities grouped per common month of birth, ~50 per group, as found in Starsky and Cox's 2004 book *Sextrology – the Astrology of Sex and the Sexes*, to see if random people [N=40] could intuitively discern what group of people the belonged to. Results were negligibly significant, but biased because many of the participants knew the signs of many celebrities.
[109] Nyborg, Helmuth. (1994). *Hormones, Sex, and Society – the Science of Physicology.* London: Praeger.

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(b) Newton's law of universal gravitation (Wikipedia);
[URL]: http://en.wikipedia.org/wiki/Newton%27s_law_of_universal_gravitation\
[112] Pease, Allan. (1981). *How to Use Body Language for Power, Success, and Love.* New York: Bantam Books.
[113] Klimek, David. (1979). *Beneath Mate Selection and Marriage – the Unconscious Motives in Human Pairing.* Van Nostrand Reinhold Co.
[114] (a) An example of the relationship between the weak nuclear force and human life is the first twice-honored Nobel laureate Marie Curie, who died due to over-exposure to radioactive materials, such as uranium. Her death near Sallanches, Savoy, in 1934 was from aplastic anemia, almost certainly due to exposure to radiation, as the damaging effects of hard radiation were not yet known, and much of her work had been carried out in a shed with no safety measures. She had carried test tubes containing radioactive isotopes in her pocket and stored them in her desk drawer, remarking on the pretty blue-green light the substances gave off in the dark. [URL]: http://en.wikipedia.org/wiki/Marie_Curie
(b) Radioactivity (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Radioactivity
(b) Weak nuclear force (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Weak_nuclear_force
[115] Definition (passion): Merriam-Webster Collegiate Dictionary (CD-ROM), 2000, version 2.5
[116] In [12.5], technically it's actually 5 O_2 molecules reacting per every 1 C_3H_8 molecule.
[117] Back-cover quotes found on David Klimek's 1979 book *Beneath Mate Selection and Marriage – the Unconscious Motive in Human Pairing.*
[118] (a) Fisher, Luchina. (2003). *Working Women Delay, Forego, Rethink Motherhood.* [URL]: www.womensenews.com
(b) Maier, Barbara. (1996). *How to cope with a strong unfulfilled desire for a child?* Biomedical Ethics—Vol. 1, No. 2.
(c) Derman, Seth, G. Dr. (1996). Reproductive Endocrinologist, The Medical Center at Princton. [URL]: www.pacpubserver.com/news/health/l-q/hm1115.html
(d) [URL]: www.census.gov/population/www/socdemo/fertility.thml
(e) Buss, D. (1994). *The evolution of desire: strategies of human mating.* New York: Basic Books.
[119] Muller, Erich. A. (1998). "Human Societies: a Curious Application of Thermodynamics." *Chemical Engineering Education,* Vol. 1, No. 3, Summer.
[URL]: http://cee.che.ufl.edu/Journals/summer1998/Müller.htm
[120] Note: the dodecabond model is based on a 3-year meta-analysis, conduced by Thims in 2001-2003, of some 80+ books; the 16 books shown are the core publications used in the construction of the dodecabond model.
[121] (a) Empty nest syndrome (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Empty_nest_syndrome
(b) Retirement (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Retirement
[122] (a) Cubical atom (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Cubical_atom
(b) Octet rule (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Octet_rule
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[124] Etcoff, Nancy (2000). *Survival of the Prettiest – the Science of Beauty*. Anchor Books.
[125] (a) Noble gas (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Noble_gas
(b) Octet rule (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Octet_rule
(c) Abegg's rule (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Abegg%27s_rule
(d) Gottman, John. (1994). *Why Marriage Succeed or Fail.* New York: Fireside.
[126] Note: the noble gases are the elements in group 8 of the periodic table are also called the 'helium family' or *neon family*; hence, building on this logic, a *human neon family* is one that is extremely stable in quantum electronic bonding tendencies.
[127] (a) *Chemical bonding* (examples):
Banana bond (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Banana_bond
Non-covalent bond (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Noncovalent_bonding
Hydrogen bond (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Hydrogen_bond

Mechanical bond (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Mechanical_bond
Triple bond (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Triple_bond
(b) Human bonding (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Human_bonding
Attachment theory (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Attachment_theory
Affectional bond (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Affectional_bond
Interpersonal ties (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Interpersonal_ties
Capture bonding (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Capture-bonding
[128] Heisenberg, Werner. (1932). 'Uber den Bau der Atomkerne,' *Zeitschrift fur Physick* 77, I.
[129] Bond length (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Bond_length
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deep impression that classical thermodynamics made upon me. It is the only physical theory of universal content which I am convinced will never be overthrown, within the framework of applicability of its basic concepts"
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(c) Spontaneous (Merriam-Webster): (a) proceeding from natural feeling or native tendency without external constraint; (b) arising from momentary impulse; (c) developed without apparent external influence, force, cause, or treatment.
(d) Early-phase human chemical reactions, especially romantic love reactions, will often be characterized by great spontaneity, i.e. they go on their own with little effort; latter-phase human chemical reactions will often be characterized by a lack of spontaneity, which then evolves to the state where a pair, in the case of a romantic love reaction, will have to spend a great amount of time and energy "working" on their relationship; this will then evolve, in many cases into the reaction state in with the reaction stops working, as characterized by phrases such as "I don't think we're going to work out anymore", or "I don't see how this is going to work?", etc.
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(c) Thermoeconomics (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Thermoeconomics
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(b) Social action (definition): any action that takes into account actions and reactions of other individuals and is modified based on those events.
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(c) According to a March 1989 letter addressed to Gibbs by Heinrich Hertz, "many of the things which I thought had been first done by Helmholtz I found in your (Gibbs) paper." (Wheeler, pg. 98).
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[48] (c) According to a March 1989 letter addressed to Gibbs by Heinrich Hertz, "many of the things which I thought had been first done by Helmholtz I found in your (Gibbs) paper." (Wheeler, pg. 98).
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(b) Total derivative (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Total_derivative
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[URL]: http://www.humanthermodynamics.com/HT-books.html
(b) Note: in regards to the origin of this science, Thims originally wrote up a chapter overview of this topic in the 2004, 333-page, book *Human Thermodynamics III*; the book as a whole was reviewed by a number of people around Chicago. Then, on 01/23/05 as a favor for a 20-year-old friend (a cheerleader, model, and homecoming princess), who had an estranged father living on the other side of the country that she didn't associate with, and whose mother and grandmother were both murdered a month prior [over an insurance scam], Thims took a late chapter from the third volume, and wrote up a quick, easy-to-read 15-pg overview, as to where a person goes, in reality, when they die—according the laws of human thermodynamics. Next, on 02/03/05 after filtering this 15-pg overview through nine people for respectfulness and agreeability, Thims then showed it to his 20-year-old friend—she loved it! Specifically, after reading a 24-pg version of CT, on 02/03/05: she replied: "It's awesome! … It's way better than going to the psychic; she didn't tell me anything."
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[URL]: http://en.wikipedia.org/wiki/Thermodynamic_variable
[176] (a) As to scientifically answering the first question, i.e. "what happens when you die", this subject of study is called *cessation thermodynamics*. Essentially, what defines someone as a person (fundamental particles), it is a guarantee that this quantity is conserved, according to the first law of thermodynamics; and transferred either constructively or destructively into subsequent generations. A first draft workable model, built on this premise, was formulated in 2005 called *Cessation Thermodynamics*.
(b) Thims, L. (2002). *Cessation Thermodynamics*. Chicago: IoHT Publishing; Bookstore
[URL]: http://www.humanthermodynamics.com/HT-books.html#anchor_87
(c) For testing purposes, 100 copies of this (100-page) manuscript were given to an assortment of college-educated people who read it and then were queried to determine if they agree (overall) or disagree (overall) with the premise of the hypothesis presented; 87% of these reviewers agreed that the overall concept: *'sits well in their stomach';* see comments:
[URL]: http://www.humanthermodynamics.com/Testimonials.html
[177] Street Poll ('05) "What is humankinds present-day greatest philosophical conundrum?" Conducted by Libb Thims in by polling people in person in Chicago [N=81 votes].
[URL]: http://www.humanthermodynamics.com/index.html#anchor_279
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[186] (a) Sloughing Hypothesis (HT Glossary);
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(b) Note 1: Human molecular integument (skin) accounts for 15% of its mass; Earth molecular integument (lithosphere, hydrosphere, atmosphere, biosphere) accounts for 4% of its mass
(c) Note 2: Human molecular integument (skin) renews once every 1-3 months (600 times per lifecycle - 75 years); Earth molecular integument (lithosphere, hydrosphere, atmosphere, biosphere) renews once every 26-30 million years (192 times per lifecycle – 15 billion years)
(d) Note 3: Solar molecular integument (magnetic skin) renews once every 11-22 years; Read: article magnetic skin article: "Sun shed its skin like a snake", by David Whitehouse,
[URL]: http://flatrock.org.nz/topics/science/earth_no_passive_victim.htm
(e) Note 4: This hypothesis was formulated in July of 2005 by Libb Thims after reading Eric Schneider & Dorian Sagan's: *Into the Cool -- Energy Flow, Thermodynamics, and Life* [page 204, paragraph 2, first 3 sentences].
[187] Exodermal regeneration cycle (HT Glossary);
[URL]: http://www.humanthermodynamics.com/Glossary/E.html#anchor_537
[188] Note: this Recapitulation and Conclusion was modeled on the Recapitulation and Conclusion section of Chares Darwin's 1859 *Origins of Species* in his honor.
[189] (a) Corning, P. (2002). "Thermoeconomics – Beyond the Second Law". Source:
[URL]: http://www.complexsystems.org/abstracts/thermoec.html
(b) Margulis, Lynn. & Sagan, Dorion. (1995). *What is Life?* Berkeley: University of California Press.

(c) Schneider, Eric. D. & Sagan, Dorion. (2005). *Into the Cool – Energy Flow, Thermodynamics, and Life*. Chicago: University of Chicago Press. is Life? (Wikipedia);
[URL]: http://en.wikipedia.org/wiki/What_is_Life%3F_%28Schr%C3%B6dinger%29
[191] (a) Gibbs free energy (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Gibbs_free_energy
(b) Entropy and life (Wikipedia); [URL]: http://en.wikipedia.org/wiki/Entropy_and_life
[192] (a) Schrödinger's 1944 book *What is Life?* was based on a course of public lectures delivered under the auspices of the Dublin Institute for Advanced Studies at Trinity College, Dublin, in February 1943. The audience, of about 400, which did not dwindle through-out the lecture, was warned initially, according to Schrodinger, 'that the subject-matter was a difficult one and that the lectures could not be termed popular, even though the physicist's most dreaded weapon, mathematical deduction, would hardly be utilized.'
(b) Schrödinger states on page one, chapter one, that the entire lecture will focus on one important question, namely 'how can the events in space and time which take place within the spatial boundary of a living organism be accounted for by physics and chemistry?' He continues, 'the preliminary answer which this little book will endeavor to expound and establish can be summarized as follows: the obvious inability of present-day physics and chemistry to account for such events is no reason at all for doubting that they can be accounted for by those scientists.'
(b) Margulis, Lynn. & Sagan, Dorion. (1995). *What is Life?* (pg. 1). Berkeley: University of California Press.
[193] Schrödinger, Erwin (1944). *What is Life?* (note to chapter six, page 74-75, in 2000 reprint edition). Cambridge University Press.
[194] (a) Fenn, John, B. (1982). *Engines, Energy, and Entropy – a Thermodynamics Primer*. W.H. Freeman and Co.
(b) John B. Fenn (Wikipedia); [URL]: http://en.wikipedia.org/wiki/John_Bennett_Fenn
(c) One could easily argue that the number of Nobelists derived from the works of Gibbs and Clausius (combined) far outweigh any other set of scientists, ever. Gibbs held Clausius in great esteem; the Clausius quotes "Die Energie der Welt ist contstant" (the first law) and "Die Entropie der Welt strebt einem Maximum zu (the second law) were Gibbs' opening quotes to his monumental 1876 "On the Equilibrium of Heterogeneous Substances."
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[URL]: http://en.wikipedia.org/wiki/On_the_Equilibrium_of_Heterogeneous_Substances
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(2) Libb Thims (Location = "Flats" Cleveland, OH); Chinese Symbol = "Change"; photo taken by random club patron.
Book End: Mating of Large Red Damselfly (*Pyrrhosoma nymphula*) with male on top, in Ciney, Belgium, configured in the shape of a heart, a common symbol of love (photo) by: Luc Viatour, Date: 2006; (GNU FDL) Nikon case D50 optical Sigma 17-70mm,
[URL]: http://en.wikipedia.org/wiki/Image:Pyrrhososma_nymphula_Luc_Viatour.jpg
Chapter Ten: (1) Three Putti Image (public domain); as found on the title page of P. J. Macquer's *Elemens* (2nd ed, 1753); also as found in Andrew Cunningham and Nicholas Jardine's 1990 *Romanticism and the Sciences* (pg. 267) Cambridge University Press; also found on the book cover of Mi Gyung Kim's 2003 *Affinity, that Elusive Dream – a genealogy of the Chemical Revolution* (and two different Putti diagrams on pg. 202).
(2) Love in Egyptian hieroglyphics (hand drawn by Thims); similar diagrams found in the Urban, Sylvanus. (1849). *The Gentleman's Magazine,* chapter: "The Hieroglyphical System of the Ancient Egyptians" (pg. 245), Vol. XXXII, Jul-Dec. London: John Bowyer Nichols & Son.; as well as in Jim Loy's 1998 *Egyptian Hieroglyphic Dictionary*.
[URL]: http://www.jimloy.com/hiero/dict12.htm
(3) Two people holding, the sun, two people arguing (animations); all from Animation Factory; rights paid.
(4) Table de Mr Geoffroy 1718 (public domain); copies found in Arthur Greenberg's 2000 *A Chemical History Tour – Picturing Chemistry from Alchemy to Modern Molecular Science* (pg. 119); in J.R. Partington's 1937 *A Short History of Chemistry* (pg. 322); as well as:
Image [URL]: http://en.wikipedia.org/wiki/Image:Affinity-table.jpg
Chemical affinity [URL]: http://en.wikipedia.org/wiki/Chemical_affinity
(5) Cullen's 1750s single elective affinity diagrams (public domain); annotated with modern reaction (shown on the right in MS Word); examples found in: Crosland, M. P. (1959). "The use of diagrams as chemical 'equations' in the lecture notes of William Cullen and Joseph Black." *Annals of Science*, Vol 15, Num 2, June.
(6) Cullen's 1750s single and double affinity diagrams (public domain); examples found in: Crosland, M. P. (1959). "The use of diagrams as chemical 'equations' in the lecture notes of William Cullen and Joseph Black." *Annals of Science*, Vol 15, Num 2, June.
(7) Cullen's 1750s affinity lever diagrams (public domain); examples found in: Crosland, M. P. (1959). "The use of diagrams as chemical 'equations' in the lecture notes of William Cullen and Joseph Black." *Annals of Science*, Vol 15, Num 2, June.
(8) Limbourg's 1758 Affinity table (public domain); as found in Mi Gyung Kim's 2003 *Affinity, that Elusive Dream – a genealogy of the Chemical Revolution* (pg. 225); Limbourg's Nouvelle Table des Affinties chymique, from Demach, *Recueil de Dissertations physico-chimiques, presentees a diffrentes adademies* (Paris: Nyon and Barrois, 1781).
(11) Bergman's (single elective affinity) decomposition of calcareous hepar by vitriolic (public domain); as found in Torbern Bergman's 1775 *Dissertation on Elective Attractions.*
(12) Bergman's (double elective affinity) decomposition of nitrated silver and common salt (public domain); as found in Torbern Bergman's 1775 *Dissertation on Elective Attractions.*
(13) Surface estate diagram (made by Libb Thims); using MS word text box and tools.

(14) Demachy's 1781 elective affinity reaction (public domain); as found in Arthur Greenberg's 2000 *A Chemical History Tour – Picturing Chemistry from Alchemy to Modern Molecular Science* (pg. 119); from *Recueil de Dissertations Physico-Chimiques Presentes a Differentes Academies* (Jacques Francois Demachy, Paris, 1781).
(15) Goethe's human double elective affinity diagram (made by Libb Thims); using MS Word.
(16) Thermodynamic system (made by Libb Thims); using MS Word. Image found here:
Thermodynamic system [URL]: http://en.wikipedia.org/wiki/Thermodynamic_system; similar example found in Yunus Cengel and Michael Boyles' 2002 *Thermodynamics – an Engineering Approach, 4th Ed.* (pg. 8).
(17) Human particle study in a potential energy well (made by Libb Thims); using MS Word; similar diagrams found in G. M. Anderson's 1996 *Thermodynamics of Natural Systems* (pg. 3)
(18) Activate complex diagram (made by Libb Thims); using MS Word.
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(2) René Magritte's 1933 oil on canvas Elective Affinities (painting) (public domain); Oil on canvas. 41 x 33 cm. example found here:
° Elective Affinities [URL]: http://en.wikipedia.org/wiki/Elective_affinity
° René Magritte [URL]: http://en.wikipedia.org/wiki/Ren%C3%A9_Magritte
(3) Lavoisier's ice-calorimeter (public domain); from Antoine Lavoisier's 1787 Elements of Chemistry; [URL]: http://en.wikipedia.org/wiki/Image:Ice-calorimeter.jpg; Modern reaction calorimeter (public domain); Image from Syrris Ltd from: syrris.com; the Lara coflux system is developed by Syrris in collaboration with Radleys and Ashe Morris; [URL]: http://en.wikipedia.org/wiki/Image:Lara_Coflux.jpg
(4) Host-Guest diagram (GNU-FDL); made by User:M stone; date: 20 Jan 2007; note: picture generated from a crystal structure reported by Julius Rebek, Jr. and coworkers in Chemistry-A European Journal, 1996, 2, 989-991. It shows a dimeric molecular assembly that contains a single nitrogen molecule.
[URL]: http://en.wikipedia.org/wiki/Image:Encapsulating_Assembly_of_Nitrogen_by_Rebek.jpg
Chapter Twelve: (1) 1995 book cover to Klaus, Kennell, and Klaus' *Bonding – Building the Foundation of Secure Attachment and Independence.* Reprinted by permission of Da Capo Press, a member of Perseus Books Group; ***Cost = $200.00***.
(2) Lorenz's 1937 Imprinting (public domain); example image found here:
[URL]: http://en.wikipedia.org/wiki/Imprinting_%28psychology%29
(3) Bonded rhesus monkeys (free content use SXC license); photographer: Nikita Golovanov; date: 12/26/04; description: Rhesus Macaques (*Macaca mulatta*) from Hainan island, China
° Nikita Golovanov [URL]: http://www.sxc.hu/profile/kit1578; image found here:
° [URL]: http://en.wikipedia.org/wiki/Image:Rhesus_Macaques_4528.jpg
° [URL]: http://www.sxc.hu/photo/229342
(4) Gay bonding (painting) (public domain); description: a mural of a female couple kissing on the City College of San Francisco student union in San Francisco.
[URL]: http://en.wikipedia.org/wiki/Image:Lesymuralccsf.JPG
(5) Samantha Casey (photo); description: Miss Virginia Teen 2006 Samantha Casey (delegate to Miss Teen USA); caption: Capt. Richard Snyder welcomes Miss Virginia 2006 Amber Copley and Miss Virginia Teen 2006 Samantha Casey aboard the amphibious assault ship USS Bataan (LHD 5). Snyder and Casey were visiting as a part of Norfolk city tour. While aboard Bataan, they toured the ship, greeted Sailors and took publicity photos for their upcoming events; photo by: US 3rd Class Kleynia R. McKnight; date: May 3, 2006; [URL]: http://en.wikipedia.org/wiki/Image:Samantha_Casey.jpg
(6) Dewey Redman (photo); photo by: nomo/michael hoefner; date: June 05, 2006; description: Moers Festival 2006; (C.C. Attribution ShareAlike 2.5 License);
[URL]: http://en.wikipedia.org/wiki/Image:Dewey-redman-sw2.jpg
Chapter Thirteen: (1) Friendship bond (picture); photo by: Fotograf: Benjamin Gimmel; (GNU FDL);
[URL]: http://en.wikipedia.org/wiki/Image:Freundinnen.jpg
(2) Primary, Secondary, and Tertiary Human Chemical Bond (made by Libb Thims); MS Word.
(3) Couple with good chemistry (public domain); description: Postcard of France - French Army - a soldier in love - unknown Year, approximately 1914
[URL]: http://en.wikipedia.org/wiki/Image:Couple-Militaire_amoureux_01-vers_1914.JPG
(4) Bonding geometry of water molecule (diagram); author: Wikipedian Booyabazooka; date: 2006-05-17; The file was created in inkscape.

[URL]: http://en.wikipedia.org/wiki/Image:Water_molecule_dimensions.svg
(5) Butane diagram (public domain); made by: User: Benjah-bmm27; date May 27, 2006.
[URL]: http://en.wikipedia.org/wiki/Image:Butane-3D-space-filling.png
isobutane diagram (public domain); made by: User: Edgar181; date: Nov 03, 2006.
[URL]: http://en.wikipedia.org/wiki/Image:Isobutane3.png
(6) Bonding Geometries in the Alpha Di-Beta Clique Structure (made by Libb Thims); using MS word and free content (public domain) images from:
Equilateral triangle [URL]: http://en.wikipedia.org/wiki/Image:Triangle.Equilateral.svg
Isosceles triangle [URL]: http://en.wikipedia.org/wiki/Image:Triangle.Isosceles.svg
Scalene triangle [URL]: http://en.wikipedia.org/wiki/Image:Triangle.Scalene.svg
(7) Mean Girls, 2004 (film); source: © 2004 by Paramount Pictures. All Rights Reserved. This image is of a (promotional) cover of an film, and the copyright for it is most likely owned by either the publisher of the album or the artist(s) which produced the recording or cover artwork in question. Rational for fair use: It is believed that the use of *low*-resolution images of such covers for purposes such as criticism, comment, news reporting, teaching, scholarship or research, etc., is in the domain of *fair use* under US copyright law. The image does not limit the copyright owners' rights to distribute the film in any way. The poster is being used for informational purposes only, and its use is not believed to detract from the original film in any way. [URL]: http://en.wikipedia.org/wiki/Image:Mean_Girls_movie.jpg
(8) Quark relationship (made by Libb Thims); using MS Word.
(9) Human relationship (made by Libb Thims); using MS Word.
(10) Javelin throwing competition (photo); source: IanAndWendy.com (GNU FDL); Photo gallery from the Heiva Festival in Papeete; description: Photo taken by Ian Sewell, July, 2006. Javelin throwing competition at the Heiva Festival in Papeete.
[URL]: http://en.wikipedia.org/wiki/Image:HeivaJavelinThrowing.JPG
[URL]: http://www.ianandwendy.com/OtherTrips/SouthPacific/
Chapter Fourteen: (1) Northern gannets pair-bonding (picture); author: Al Wilson; description: Northern Gannets (*Morus bassanus*), Bonaventure Island, Near Perce, Gaspe Penninsula, Quebec; date: August 2006 (C.C. Attribution ShareAlike 2.5 License).
° Al Wilson [URL]: http://www.naturespicsonline.com/
° Image [URL]: http://en.wikipedia.org/wiki/Image:Two_Gannets_edit_2.jpg
(2) New mother breast-feeding (drawing) (public domain);
[URL]: http://en.wikipedia.org/wiki/Image:She_sit_nursing_her_baby.gif
(3) New fathers walking their kids (picture); photographer: Johannes Jansson; photo from the official Nordic Council website, Attribution License.
° Image [URL]: http://en.wikipedia.org/wiki/Image:Pappaledighet.jpg
° Source (Nordic Council Website); [URL]: http://www.norden.org/nordbild/
(4) Nodes and ties (image) (public domain); author: Wikipedian Wykis; date: Jan 30, 2007.
[URL]: http://en.wikipedia.org/wiki/Image:Social-network.svg
(5) Granovetter's 1969 weak tie model (made by Libb Thims); using MS Word.
(6) Weak tie hypothesis diagram (made by Libb Thims); using MS Word.
(7) Human-animal bond (picture); (public domain); author: anonymous; description: Happy man with dog;
[URL]: http://en.wikipedia.org/wiki/Image:Man_and_dog.jpg
Chapter Fifteen: (1) Stendhal's 1822 depiction of crystallization (drawing) (public domain); description: drawn by Stendhal on the back of a playing card; as found in Stendhal's 1821 *On Love* (pg. 290); description in the appendix. Penguin Classics, 2004 reprint ed.
(2) Phenethylamine (2-D structure) (GNU FDL); made by User:Cacycle, date: 24 Sep 04,
[URL]: http://en.wikipedia.org/wiki/Image:Phenethylamine_structure.png
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[URL]: http://en.wikipedia.org/wiki/Image:Amphetamine-2D-skeletal.png
Amphetamine (space-fill model) (GNU FDL), made by: User: Sbrools, date: 05/08/07,
[URL]: http://en.wikipedia.org/wiki/Image:Amphetamine-3d-CPK.png
(3) substrate-enzyme diagram (diagram) (public domain); author: Wikipedian Tim Vickers; date: Oct 11, 2006. [URL]: http://en.wikipedia.org/wiki/Image:Induced_fit_diagram.svg

(4) Template assembly diagram (made by Libb Thims); using MS word; similar diagram found in Watson, Hopkins, Robert, Steitz, and Weiner's 1987 *Molecular Biology of the Gene, 4th Ed.* (pg. 66), The Benjamin/Cummings Publishing Company, Inc.
(5) Guanine≡Cytosine (diagram) (public domain); author: Isilanes; date: May 10, 2007; description: Guanine/Cytosine Watson and Crick base pair. I made it with ChemTool, then modified with the help of Inkscape. [URL]: http://en.wikipedia.org/wiki/Image:GC_DNA_base_pair.svg
(6) Adenine=Thymine (diagram) (public domain); author: Isilanes; date: May 10, 2007; description: Guanine/Cytosine Watson and Crick base pair. I made it with ChemTool, then modified with the help of Inkscape. [URL]: http://en.wikipedia.org/wiki/Image:AT_DNA_base_pair.svg
(7) Gecko walk up a glass wall (picture); author: w:User:Lpm; date: Dec 17 2006; description: Head and front legs of a Gecko (unspecified species, leaf-shaped tail) (GNU FDL);
[URL]: http://en.wikipedia.org/wiki/Image:Gecko_Leaftail_1.jpg
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[URL]: http://www.humanthermodynamics.com/HT-history.html
(2) Attractiveness vs. Intelligence plot (made by Libb Thims); using MS word annotation.
(3) Georgi P. Gladyshev (photo); used with permission of Georgi P. Gladyshev; Image found on the back cover of 2003 book *Supramolecular Thermodynamics is the Key to Understanding Phenomenon of Life – What is Life from a Physical Chemists Point of View.* (in Russian). Moscow: Izhevsk; Image as found also here:
[URL]: http://en.wikipedia.org/wiki/Image:Georgi-Gladyshev.jpg
(4) Gladyshev's spatial-temporal hierarchy (diagram); used with permission of Georgi P. Gladyshev; image found in Gladyshev's 1997 *Thermodynamic Theory of the Evolution of Living Beings* (pg. 24). Nova Science Publishers; image found here:
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